



Feed X

The Path to Legally Introducing a New Fishmeal Recipe

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Executive Summary

From the perspective of sustainability, changes in the aquaculture operations of salmon and shrimp are desirable. Nevertheless, such alternatives must comply with the law. Unfortunately, there are as many legal regimes as there are states and blocs of states. Thus, the sheer amount of legislation is staggering. As a consequence, it is only possible to do a legal assessment of specifically described ingredients, processes, techniques or methods for a few key states.

This legal report reviews the legal conditions imposed on alternative, potentially more sustainable feed ingredients, processes, techniques and methods in aquaculture fisheries of salmon and shrimp, taking the EU and the U.S. as an example. With regard to feed ingredients, the assessment is focused on food and feed safety with regard to approval, labelling, hygiene and quality. The main other legal fields that come into play, in particular for processes, techniques and methods, are waste law and maritime law.

Remarkable findings are:

- First, that the legal approach for salmon and shrimp is the same. Therefore, it is expected that the legal assessment can also be useful for other aquaculture species.
- Second, it is striking that so many alternatives are already approved and on the market, and therefore easy to introduce in aquaculture both in the EU and the US. Overall, the results show that regulation will frequently not constitute an obstacle to the introduction of alternatives. One should not become overly optimistic though. Where approval is needed, it can be complex and time-consuming. In general, the more novel an ingredient is (e.g. a production that is not commonly used, using special strains of bacteria, yeast, algae and so on), the more complex and time-consuming the legal approval procedure becomes.
- Third, while EU and US legislation are perceived to be very different, the outcomes are frequently the same. Important differences between the EU and the US arise with regard to the use of manure and sludge to feed animals and potential cannibalism. While the EU bans these practices, the US does not.
- Fourth, at the international level, NGOs have added sustainability requirements. However, meeting these requirements is voluntary, and is only visible through labeling.

This document has been peer reviewed for accuracy and quality of content by at least three independent experts from credible organisations including research universities, WWF and business.

Although the utmost care has been taken to identify and correct all typographical errors, some may still exist and if found write to info@projectxglobal.com. UK spelling is used in most cases.

Introduction

This legal report is part of the Feed-X Project. It's overall aim is to source, test, finance and scale alternative, sustainable feed ingredients into the global feed industry to increase their sustainability and reduce their impact on climate change and biodiversity loss. The Feed X aquaculture project, supported by Climate Kic, is concerned with removing barriers for sustainably fed aquaculture, and in particular the adoption of alternative, sustainable feed for salmon and shrimp as two species with wholly different feed requirements and industry structures. The assessment comprises 12 criteria, which are assessed through thematic lenses, including a legal lens.

The legal lens focuses on de-risking the element of legal compliance. Compliance with the law is a critical criterium, however it is one where there is room for interpretation and exploration of what it will take to introduce ingredients, processes, technologies and innovative methods under the varying legal frameworks of states. Given that the legal regimes differ across states and blocs of states, the world market is fragmented. As a consequence of the different legal frameworks across states, some innovations can therefore be introduced at a global level, whereas others can only be legally introduced in some markets.

This legal report and the accompanying table “Ingredient De-Risking – Legal Lens” provide an overview of the legal requirements of the EU and the USA. We selected these two legal regimes due to their importance as key aquaculture regions and their high level of protection in the interest of food and feed safety, consumer and environmental protection. The outcomes of our legal assessment of the applicable legislation indicate the ease or difficulty with which specific alternative feed ingredients, processes, technologies and innovative methods are expected to comply with the legal requirements which determine whether a new ingredient can be legally used in the EU or the US. It deserves further legal scrutiny, but given their high standards, it likely that EU and US approved alternatives can also be introduced at a global scale in compliance with the applicable legislation of other countries and blocs of states.

Purpose and research question

Our aim is to assess the legal conditions, which determine the legal feasibility of the use of selected potential alternative feed ingredients or approaches to feed salmon and shrimp.

With the following outcome:

- Identification, and understanding (screening) of national and international trade regulations affecting market entry of specific feed alternatives in the key regions (EU, USA) of the lead corporate (Skretting).

The expected ease or difficulty to meet EU or US legal requirements constitutes a criterium in the choice between selected potential feed ingredients, processes, technologies and innovative methods.

As such, the main legal research question is:

“To what extent is the introduction of potentially more sustainable feed alternatives for aquaculture fisheries attainable under the current legal frameworks of the European Union and the United States?”

Approach and methods

In order to answer our research question, we opted for a comparative legal doctrinal methodology, which entails a comparison between the legal frameworks of two or more important markets in the area of aquaculture.¹ For this research, the legislative frameworks of the European Union (herein: EU) and the United States (herein: U.S.) were selected. This choice was made after an assessment of the major players in the salmon and shrimp value chains.² The aquaculture sector can be divided into producers of farmed fish and producers of the farmed-fish feed.³ Asia is where the vast majority of aquaculture fish farming takes place,⁴ but the United States is the world's largest and most advanced producer of formulated animal diets, followed by the European Union and China. Moreover, major fish farms are present both in the EU and the U.S. For salmon, there are five key producer countries according to the PwC² report namely; Norway, UK, US, Chile, Australia. Key markets are US, France, Germany, UK and Brazil. For shrimp, key producers are India, Vietnam, Indonesia and Ecuador, and key consumers are the EU, US, Vietnam and China.

Although each country has its own peculiarities, in general the EU and the U.S. set the highest standards. Therefore we consider it worthwhile to analyse these two legal systems to assess the legal requirements for the introduction of alternative fish ingredients, which could then be introduced at a global level too. We are however, aware that differences in rules apply between the EU and the USA and between them and Asian and South American countries. As a consequence, alternative ingredients, processes, technologies and innovative methods, which are not easy to introduce or experiment with in the EU or the USA, could be introduced or tested elsewhere. A more pragmatic reason for the selection of the EU and the USA is due to the limitation of language on the part of the legal lens researchers and the necessary limitation, which follows from the time-frame of the project.

The legal area is very detailed and complex. EU feed legislation alone is more than 70 000 pages. The sheer amount and complexity of the legal regimes led us to present the results of the research not only in text but also in table form, in the document titled "Ingredient De-risking – Legal Lens". The selection of the specific items of the table reflects the research of the Feed X Environmental and Nutritional Lenses. This choice was made because specific information is required to make a legal assessment for a very specific item. The added benefit of adhering to the environmental and nutritional selection of items is that it optimises the integration of the legal lens with the environmental and nutritional lenses. The legal table therefore contains the same categories, sub-categories, and relevant items for evaluation.

In the Legal Lens table, each item is assigned a colour based on the expected ease of introduction in compliance with the legal regime of the EU and U.S. markets. The table makes a distinction between feed for shrimp and feed for salmon, even though in most cases this distinction makes no difference from a legal perspective. The colours chosen to indicate ease of introduction in compliance with the legal regime follow a modified "traffic-light" model. Red corresponds to not possible to introduce under the current legal framework (in short: unattainable) and green to introduction is in compliance with the legal regime. The specific definitions of each of the colours is presented in a "Key" in the table document, but can also be found below:

¹ Palmer, V. V., & Palmer, V. V. (Eds.). (2012). *Mixed jurisdictions worldwide: The third legal family*. Cambridge University Press.

² PwC report, Vassbotten, M., et al (2018) *Market readiness PwC Norway*, Bergen

³ Kathryn White, Brendan O'Neill, and Zdravka Tzankova. "At a crossroads: will aquaculture fulfill the promise of the blue revolution." (Silver Spring Meriland, 2004), 4.

⁴ *Ibid*, 4.

Table 1: ‘Key’ presenting the definition of each of the colours used in the project’s assessment of ingredient viability

KEY:	
Red	Legal compliance is unattainable under the current legal framework - Under the current legal framework it is not possible to get the ingredient/process approved and released on the market
Dark Orange	Legal compliance is not attainable in the short term - neither this ingredient/process, nor a similar ingredient/process, is yet approved
Light Orange	Legal compliance is attainable – a similar ingredient/process is approved but the ingredient/process itself is not
Green	Compliant - this ingredient/process is already legally approved and can enter the market
Gray	Unknown or insufficient data available - either further research is needed or no legal materials are available

This report is divided into two parts. The first part describes the *Generally Applicable Legislation*, under both the EU and U.S. legal frameworks, that is generally applicable to all the ingredients. The second part is an extensive Annex containing the *Ingredient Specific Legislation*, which breaks down for each ingredient why the ingredient was assigned a certain colour, and under which conditions a specific ingredient can enter the EU or US market (labelling, ingredient content percentages, etc.). Each section of the Annex has been titled to match:

- First the broad category on sources of ingredients, e.g.: Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO2 and energy.
- Second the type of ingredient, e.g.: Protein - processed or concentrated - or starch from locally available food waste stream, and
- Third the actual ingredient itself, e.g. Apple pomace.

It is important to note that broad category (1) - (7) contain items which fall under the legal definition of feed ingredients. However, from category (8) onwards, the items refer to various aquaculture processes, technologies, and innovative methods. Legally speaking, this means that other legal regimes than food safety have to be complied with, such as maritime law and state-specific aquaculture regulation. Unfortunately, a significant number of processes are marked “grey” in these categories. Grey symbolizes that no data is available, or that more specific information about the process or technology is required to assess their legality.

Generally Applicable Legal Framework

International law

The legality of feed ingredients for aquaculture is addressed at various levels, including internationally. One of the most recent aquaculture documents at the international level was the Bangkok Declaration, which proposes a strategy for aquaculture development beyond the year 2000. In Article 3(12), the Declaration acknowledges the importance of improving the use of agricultural

and fishery by-products, and basing feeding strategies, wherever possible, on the use of renewable feed ingredient sources. These goals are well aligned with those of the Feed X Project.⁵

At the international level, the main international governmental organization is the FAO (Food and Agriculture Organization of the United Nations). The FAO approaches aquaculture from the perspective of its efforts to defeat hunger. Their objective is to achieve food security and make sure that people have regular access to high-quality seafood. As such, it plays an important role in providing trustworthy information on aquaculture governance, resources, technologies, as well as utilization and trade. However, the FAO plays little to no role in the certification of ingredients for market access.

Among the NGOs that deal with aquaculture, one of the most influential is the ASC (Aquaculture Stewardship Council). The ASC, like other certification schemes, addresses sustainability concerns at a global level. The ASC provides voluntary standards for the aquaculture industry in order to certify environmentally and socially responsible seafood. It has eight initial standards, which were born out of numerous multi-stakeholder round-tables, known as the Aquaculture Dialogues, initiated and coordinated by the World Wide Fund for Nature (WWF).⁶ The ASC can certify both farm operations and their chains of custody. While adherence to the ASC standards is voluntary, their certificate shows that the aquaculture operation promotes better-managed fish farming, which can meet the growing demand for responsible aquaculture products, and reduce negative environmental and social impacts.⁷

Another important standard is set by the Marine Ingredients Organisation (IFFO). It has developed a Global Standard and Certification Programme for the Responsible Supply of Fishmeal and Fish Oil.⁸ The IFFO's responsible supply conditions are centred on three key pillars: (1) responsible sourcing: fishery material from fisheries that comply with the key principles of the FAO Code of Conduct for Responsible Fisheries; (2) responsible traceability of fishmeal and fish oil back to fisheries that are compliant with this standard; (3) responsible production of safe fishmeal and fish oil. Similar to the ASC's certification scheme, the IFFO's standards are voluntary. Compliance demonstrates that the certified aquaculture operation promotes better-managed and responsible fish farming.⁹

EU law

The EU applies an extensive legal framework both on aquaculture farming and feed ingredients in general. The main pieces of legislation are first the 2009 Regulation (EC) No 767/2009, which regulates the placing on the market and use of feed, and second, and equally relevant, the 2017 revised EU Catalogue of Feed Materials (EU) Regulation 2017/1017, which provides an extensive list, in its Annex C, of the ingredients that may be used for a feed material complying with the requirements of the entry concerned.¹⁰ If the ingredient constitutes a feed additive, it has to obtain authorisation under Regulation 1831/2003.¹¹ This Regulation defines feed additives as substances, micro-organisms or preparations, other than feed material and premixtures, which are intentionally

⁵ The Bangkok Declaration and Strategy (2002), Art. 3(12), ISBN: 974-85935-1-17.

⁶ Aquaculture Stewardship Council "Farm Standards" (ASC Website, 18 December 2018) <<https://www.asc-aqua.org/what-we-do/our-standards/farm-standards/>> accessed 18 December 2018.

⁷ Ibid.

⁸ The Marine Ingredients Organisation "Global Standard for Responsible Supply – Certification Requirements" (IFFO, June 2014, United Kingdom). Accessed 10th January 2019 at <<https://www.iffors.com/sites/iffors/files/2017-06/IFFO%20RS%20Standard%20Issue%201.6%20Eng%20June%202014.pdf>>

⁹ Ibid.

¹⁰ Commission Regulation (EU) 2017/1017 of 15 June 2017 amending Regulation (EU) No 68/2013 on the Catalogue of feed materials [2017] OJ L 159/48, Annex 3.

¹¹ Regulation of the European Parliament and of the Council (EC) 1831/2003 on additives for use in animal nutrition [2003] OJ L 268/29.

added to feed or water in order to improve the quality of feed and food from animal origin, or to improve the animals' performance and health. The authorization criteria are that the additive has no harmful effects on human and animal health and on the environment. In addition, it may not mislead the user or mislead or harm the consumer. If a manufacturer or importer wants to place a new ingredient on the market, they have to obtain approval in accordance with the procedures of these Regulations.

The substantive general entry requirement for feed business operators using a feed material entered in the Catalogue is to ensure that it complies with Article 4 of the 2009 Regulation (EC) No 767/2009, which deals with the Safety and Marketing Requirements of feeds entering the market. This article prescribes that feed may only be placed on the market and used if it is safe and if it does not have a direct adverse effect on the environment and animal welfare. In addition, feed business operators which place feed on the market have to ensure that the feed a) is sound, genuine, unadulterated, fit for its purpose and of merchantable quality, and b) is labelled, packaged and presented in accordance with the other provisions of this Regulation and with other applicable EU legislation.

Approved ingredients (marked green in our table) meet the above requirements. The approval of ingredients which are similar to already approved ingredients (marked light orange) is expected to be attainable in the short term assuming that they demonstrably meet the above mentioned specifications. By contrast, for non-approved ingredients, which are not similar to approved ingredients, this procedure may take a while. The same applies to GMO feed irrespective of similarities to already approved GMOs, given that the registration procedure for GMOs under Regulation (EC) 1829/2003 on GMO food and feed requires more extensive safety assessments. Any further ingredient-specific requirements will be listed in the segment on that specific ingredient in the Annex on "Ingredient Specific Legislation".

Once the safety conditions are met, the main legal issues are correct labelling and compliance with requirements that safeguard the quality and traceability of the product. In this area, the EU Regulation 767/2009 is applicable once more. Article 15 contains General Labelling Requirements (type of feed, name of business, batch number, list of feed additives, etc.), and Article 16 Specific Mandatory Labelling Requirements for feed materials. Furthermore, the European Commission has adopted new rules on labelling the origin of the primary ingredient in food that will come into force from 1 April 2020.¹² The general rules on feed hygiene and traceability of feed can be found in Regulation 183/2005 on feed hygiene.¹³

Specific requirements with regard to the quality of the feed that is placed on the market can be found in other legislative acts. Annex I to Regulation 767/2009¹⁴ contains the rules on impurities and other chemical determinants, Directive 2002/32/EC lists maximum levels for undesirable substances in animal feed¹⁵ and Regulation 396/2005 contains the maximum residue levels of pesticides in or on food and feed of plant and animal origin.¹⁶ Finally, other relevant EU plans and pieces of legislation include: (1) the EU Circular Economy Action Plan,¹⁷ to which the Feed X project contributes by

¹² European Commission Press Release "Commission adopts new rules on labelling origin of primary ingredients in food" (EC, 28 May 2018), < https://ec.europa.eu/info/news/commission-adopts-new-rules-labelling-origin-primary-ingredients-food-2018-may-28_en > last accessed 5 December 2018.

¹³ Regulation of the European Parliament and of the Council (EC) No 183/2005 of 12 January 2005 on feed hygiene [2005] OJ L 35/1.

¹⁴ Regulation of the European Parliament and of the Council (EC) No 767/2009 of 13 July 2009 on the placing on the market and use of feed [2009] OJ L 229/1, Art. 4

¹⁵ Directive of the European Parliament and of the Council (EC) No 2002/32/EC of 7 May 2002 on undesirable substances in animal feed [2002] OJ L140/10.

¹⁶ Regulation of the European Parliament and of the Council (EC) No 396/2005 of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin [2005] OJ L 70/1.

¹⁷ Communication from the Commission to the European Parliament on Closing the loop - An EU action plan for the Circular Economy [2015] COM/2015/0614/1.

focusing on one of the Action Plan's priority areas - adding value to food waste; (2) The Waste Framework Directive,¹⁸ whose waste hierarchy is highly aligned with the project goals of Feed X; (3) The EU Common Fisheries Policy,¹⁹ which aims to reduce the operating costs of fish farmers practices; and finally, (5) the Marine Strategy Framework Directive,²⁰ which includes the goal to reduce the need to catch wild fish through the creation and entry into the market of new fish meal replacement ingredients.

U.S. Federal law

In the U.S., the Federal Food and Drug Administration (herein: FDA) is responsible for monitoring the safety of food and feed products. The provisions of the 2007 Federal Food, Drug, and Cosmetic Act (FFDCA) govern the use of food products, and the Regulations issued under its authority. These Regulations are published in the Code of Federal Regulations (CFR), which is updated annually.²¹ The U.S. legal system offers less ingredient-specific variation than the EU legal system. As such, this section will explain the basic system for feed ingredient approval in the United States, and the conditions of market-entry that applies equally to all ingredients in the "De-Risking" Table. If any ingredient-specific requirements do exist, they will be further expanded on in the section on that specific ingredient in Chapter 2 on "Ingredient Specific Legislation".

According to US legislation, it is possible to place on the market only products (food or feed) which fall into: a) additives; b) products generally recognized as safe. Under sections 201(s) and 409 of the FFDCA new food ingredients fall under the definition of food additives, i.e. any substance that is intentionally added to food. They are subject to premarket review and approval by the FDA. Once approved, the feed ingredient receives the status of Generally Recognized as Safe (GRAS).²² A list of GRAS approved food substances and additives for use in animal feed can be found in the CFR, under Title 21 on "Good Manufacturing or Feeding Practice".²³ The relevant sections are section 582 (582.1 to 582.7724) on "Substances Generally Recognized as Safe", section 584 (584.200 to 584.725) on "Food Substances Affirmed as Generally Recognized as safe in feed and drinking water of animals" and section 589 (589.1 to 589.2001) on "Substances Prohibited from use in animal food or feed".

The GRAS recognized status from the FDA is not a mandatory pre-requisite for market entry. An ingredient can also be marked as entirely safe with "no questions" by the FDA. That provides additional assurances of the regulatory status to end users of the ingredient and is therefore useful for importing ingredients manufactured outside the US.²⁴ GRAS status is achieved if the substance is generally recognized, among qualified experts, as having been adequately shown to be safe under the conditions of its intended use.²⁵ According to Section 409(b)(1) of the FFDCA [21 U.S.C. 348(b)(1)], anyone may file a petition proposing the issuance of a regulation. Section 409(b)(2) of the Act [21 U.S.C. 348(b)(2)] prescribes the statutory requirements for food additive petitions. The requirements for food additive petitions are discussed in greater detail in 21 CFR 171.1.

Since 2007, the FDA has agreed to permit the marketing of unapproved food additives in animal feed as long as there are no safety issues and the additive is listed in AAFCO's Official Publication. The AAFCO is the Association of American Feed Control Officials, a voluntary membership association of local, state and federal agencies charged by law to regulate the sale and

¹⁸ Directive of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives [2008] OJ L 312/3.

¹⁹ European Parliament and Council (EU) Regulation on the Common Fisheries Policy [2013] OJ L 354/22

²⁰ Directive of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) [2008] OJ L 164/19.

²¹ Code of Federal Regulations, 2018.

²² FFDCA 21 C.F.R. § 170.3(b), 2018.

²³ FFDCA 21 C.F.R. § 582, 2018.

²⁴ FDA, "Generally Recognized as Safe (GRAS)" (FDA Website, 22 March 2018)

<<https://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/default.htm>> accessed 3 December 2018

²⁵ Ibid., § 170.3(b)

distribution of animal feeds and animal drug remedies.²⁶ As such, aside from GRAS status (history of prior safe use), safety can also be established through inclusion in the AAFCO Official Publication, which is based on published data and information in peer-reviewed journals and/or safety studies.

Once the safety conditions are met, the only further condition that needs to be met prior to market entry is labelling. Under the provisions of the FFDCFA, importers of food products intended for introduction into U.S. interstate commerce are responsible for ensuring that the products are safe and labelled according to U.S. requirements.²⁷ Federal labelling conditions are outlined in CFR Section 501.110, on Animal feed labelling and collective names for feed ingredients. This section certainly applies to the Feed X ingredients, as it mentions specifically “Animal protein products”, “Forage Products”, “Grain Products”, “Plant protein products”, “Processed grain by-products” and “Roughage products”.²⁸

In addition to meeting the federal requirements, animal feed products are also subject to individual state laws. Under many state regulations, the feed label must include the following information:

- Brand Name, if any,
- Product Name;
- Purpose Statement;
- Guaranteed Analysis;
- List of Ingredients;
- Directions for Use;
- Warning or Caution Statements;
- Name and Address of Manufacturer; and
- Quantity Statement.

Once the federal conditions for safety and both federal and state conditions for labelling have been met, the ingredient is entirely eligible for lawful market entry.

Summary of Results

The introduction of alternative feed ingredients, processes, techniques and innovative methods may encounter legal barriers on its way. Given the sheer amount of applicable legislation, we limited our investigation to the legal conditions that determine the compliance of specific alternatives with international, EU and US law. It should be noted that the international rules add a sustainability dimension to the national rules, which are mainly concerned with food and feed safety. However, as the international rules are set by NGOs, they are influential but voluntary in character. Adherence, for instance to ASC, is indicated by labelling. By contrast, EU or US requirements must be complied with to maintain market access.

Our research revealed that while EU and US legislation are perceived to be very different, the outcomes are frequently the same. This is made visible in the tables below and in the larger table in the Annex. Although standards differ across countries, EU and US standards provide a high level of feed safety and consumer protection. Therefore, it is likely that an alternative, which can legally be introduced in both the EU and the US, can be introduced in aquaculture on a global scale. Another interesting outcome is that legally speaking, there is no difference between salmon and shrimp. For

²⁶ AAFCO, “AAFCO: The People Behind Animal Feed and Pet Food” (AAFCO Website, 3 December 2018) <<https://www.aafco.org/>> accessed 3 December 2018

²⁷ FDA “Importing Food Products into the United States” (FDA Website, 22 March 2018) <<https://www.fda.gov/Food/GuidanceRegulation/ImportsExports/Importing/default.htm>> accessed 3 December 2018

²⁸ FFDCFA 21 C.F.R. § 501.110, 2018

the sake of convenience we therefore omitted the distinction in the tables below. In the large table in the Annex to this report, where the results are shown per individual ingredient, process, technique or method, we offer the results of the analysis both for salmon and for shrimp. Yet the remarkable similarity in outcomes shows that this legal assessment can be useful for other aquaculture species as well.

Overall, the tables below show that regulation will usually not constitute an obstacle to the introduction of alternatives. Indeed, most of the 55 assessed items are in the *green* range (49% for EU, 56% for US). This means that albeit an alternative may be new to aquaculture, the ingredient, process, technique or innovative method in itself is already approved. The next best thing is that the alternative is in the *light orange* range (22% for EU, 13% for US). This means that it is not approved, but something rather similar is. As a consequence, it is expected that approval is likely and should not be overly burdensome. By contrast, there are only three items in the *red* category (5% for EU). Red is assigned to alternatives, which are banned under the current legal framework of either the EU or the US. This is the case with regard to feeding salmon and shrimp to salmon and shrimp. EU legislation takes a firm stance against cannibalism and this is unlikely to change. The same applies to the EU ban on the use of manure. Although of course the EU could reconsider the application of this ban to aquaculture.

Alternatives are placed in the dark orange category if they are truly new. That means that nothing similar is already on the market. Approval may be granted, but it will require effort and patience. Finally, there are quite a few items in the *grey* range (24% for EU and 31% for US). The grey category reflects that more specific information about the process or technology is required to assess their legality. For instance, some GM terrestrial plants are approved both in the EU and the US and able to enter the market, while others may not. This is why it is important to specify which terrestrial plants are considered as alternative feed. So a grey designation also reflects uncertainty, since designation would be green for approved GM plants and dark orange for non-approved varieties, given that approval for a GMO under the EU legal framework is difficult to obtain. One should therefore bear in mind that not only the green and light orange, but also the grey and the dark orange category may contain promising alternatives, which could well be introduced on the market, provided that one is willing to undertake the effort of obtaining approval.

The tables below group the items under the broad categories as defined by the category definition document developed by Skretting from the problem definition stage. Note that category (a) to (d) are feed ingredients. Their legal introduction requires meeting food and feed safety and labelling requirements. The categories (e), (f) and (g) comprise processes, techniques and innovative methods. Here, far more alternatives are in the grey range compared to the tables that show the results for alternative feed ingredients. Particularly interesting points are summed up next to the tables, however detailed explanations are in the appendix and in the overall table. Here, only the summary results and salient points are discussed.

Table 2: Category (a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO2 and energy: Total number of specific ingredients assessed were 30:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	3	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	1	4	3
Green	Compliant	17	21	22
Gray	Unknown or insufficient data available	1	2	5

EU legislation (Red Designation)

Energy waste from sludge gas

The ingredient is included in Chapter 1(5), where it is stated that:

- “All waste obtained from the various phases of the urban, domestic and industrial waste water as defined in Article 2 of Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (2), irrespective of any further processing of such waste and irrespective also of the origin of the water.”

Article 2 of the Council Directive 91/271/EEC includes “sludge”. Therefore, sludge is given the marking red.

Energy waste from manure

In its Annex III list of materials whose placing on the market or use for animal nutritional purposes is restricted or prohibited, in Regulation (EC) No 767/2009 includes in Chapter 1(1): “Faeces, urine and separated digestive tract content resulting from the emptying or removal of digestive tract, irrespective of any form of treatment or admixture.” Furthermore, digestive tract waste cannot be used under any circumstances, irrespective of any form of treatment or admixture - according to the Annex III list of materials whose placing on the market or use for animal nutritional purposes is restricted or prohibited, in Regulation (EC) No 767/2009.

Therefore, manure is given the marking red.

Use of waste heat for flocculation of proteins from waste streams (e.g. effluent)

In this instance, the Feed X project idea behind this ingredient is that during the filleting of fish, the product or its co products are intensively in contact with water. A large amount of water is needed to clean the product or the process line. During this process, soluble proteins solubilize in this water. The proteins in the solution could be precipitated by the use of “waste” heat and collected again as a protein source. Since both various types of protein and food-industry by-products have been approved for introduction as feed ingredients on the market, it could follow that waste heat for flocculation of proteins from waste streams would also be approvable. Further research is needed for exact specification. However, this practise seems to risk feeding to a species its own kind, something which is strictly forbidden under the EU legal framework to counter animal health risks, as defined in Article 11(d) or Regulation 1069/2009 on Animal by-products. Therefore, the colour marking red has been chosen.

Table 3: Category (b) Nutritional solutions creating health effects equal to or greater than fatty acids: Total number of specific ingredients assessed were 4:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	0	1	0
Green	Compliant	2	2	3
Gray	Unknown or insufficient data available	1	1	1

GMO Europe Legislation points of interest (Grey designation)

The wording of this ingredient is too broad to be pinned down specifically from a legal perspective. Some GM terrestrial plants may be approved and therefore able to enter the EU market, while others may not. This is why it is important to specify which terrestrial plants the study refers to. For instance, the EU register of genetically modified food and feed does include “Genetically modified sugar beet that expresses: a CP4 EPSPS protein confers tolerance to glyphosate containing herbicides” as an approved ingredient. Therefore, if the plant referred to was this particular GM sugar beet, this would be an approved ingredient. As such, this ingredient was given the marking grey because further specification is needed as to which GM plants it specifically refers to. It would be green for approved GM plants and dark orange for non-approved varieties, given that approval for a GMO under the EU legal framework is difficult to obtain.

Specific conditions: GMO food and feed must be labelled: the list of ingredients must indicate "genetically modified" or "produced from genetically modified [name of the organism]". For products without packaging, these words must be clearly displayed in close proximity to the product. The labelling requirements do not apply if the food or feed ingredients considered individually contain

max 0.9 % GMO and this presence is adventitious or technically unavoidable.²⁹ It is important to note that the EU labelling requirements do *not* apply on food from animal origin which was fed GMO's. Therefore, it will *not* appear on the label if salmon or shrimp was fed GMO's. This differs from the ASC label requirements, which demand that buyers are informed whether farmed salmon has been fed on GMO (transgenic) plants or raw materials derived from transgenic plants.

Table 4: Category (c) Nutritional solutions using inputs that create environmentally restorative effects: Total number of specific ingredients assessed were 3:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	0	0	0
Green	Compliant	2	3	2
Gray	Unknown or insufficient data available	0	0	1

US legislation for Insect Protein (Grey)

Insects status has not been addressed yet by US legislation. No insect species has been approved as food additive and none has submitted a dossier to demonstrate that an insect species is generally recognised as safe (GRAS). The complete lack of federal rules on insect food and feed at the federal level has caused much confusion at the state level.³⁰ A 2017 study published in the European Food & Feed Law Review found the following:

“local inspectors may close down an insect production facility or an insect restaurant, if ingredients are not from an FDA-approved source. The attitudes of health departments vary from city to city with some more accepting of insects as food than others. At the moment, approved insect sources may be difficult to find.”

The complete confusion regarding insects as feed ingredients, as explained, includes the approval of ingredients fed to insects for consumption in animal feed. As such, this feed ingredient is also marked dark orange, due to such unclear market access circumstances in the US. It should be noted that market access for insects is easier under the EU legal framework.

²⁹ Lahteenmaki-Uutela (2017), 22.

³⁰ Ibid, 25.

Table 5: Category (d) Technology solutions creating net positive effects using renewable energy, packaging waste, energy waste, sustainable transport: Total number of specific ingredients assessed 5:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	1	2	1
Green	Compliant	1	1	2
Gray	Unknown or insufficient data available	2	2	2

Table 6: Category (e) Technology solutions increasing the health, survival and growth performance of the fish/ shrimp: Total number of specific ingredients assessed was 5:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	2	4	3
Green	Compliant	0	0	1
Gray	Unknown or insufficient data available	0	1	0

Table 7: Category (f) Integrated information systems solutions increasing feed waste efficiencies: Total number of specific ingredients assessed was 4:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	2	0	0
Green	Compliant	0	0	0
Gray	Unknown or insufficient data available	4	4	4

Table 8: Category (g) Innovations moving the whole farm production footprint off land: Total number of specific ingredients assessed 4:

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	0	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	0	1	0
Green	Compliant	0	0	1
Gray	Unknown or insufficient data available	3	3	3

Overall this gives us the following results for the 55 priority solutions assessed:

Table 9: Summary table, totals were designation in the EU and US

Colour designated:	Definition	Number of specific ingredients designated same for EU and US	Number of specific ingredients designated Different for EU and US	
			EU	US
Red	Legal compliance is unattainable under the current legal framework	0	3 (5%)	0
Dark Orange	Legal compliance is not attainable in the short term	0	0	0
Light Orange	Legal compliance is attainable	4	12 (22%)	7 (13%)
Green	Compliant	21	27 (49%)	31 (56%)
Gray	Unknown or insufficient data available	10	13 (24%)	17 (31%)

Conclusion

Our research revealed that while EU and US legislation are perceived to be very different, the outcomes are frequently the same. Although standards differ across countries, EU and US standards provide a high level of feed safety and consumer protection. Therefore, it is likely that an alternative, which can legally be introduced in both the EU and the US, can be introduced in aquaculture on a global scale. Another interesting outcome is that legally speaking, there is no difference between salmon and shrimp. Yet the remarkable similarity in outcomes shows that this legal assessment can be useful for other aquaculture species as well.

Overall, the results show that regulation will usually not constitute an obstacle to the introduction of alternatives. Indeed, most of the 55 assessed items are in the *green* range (49% for EU, 56% for US). This means that albeit an alternative may be new to aquaculture, the ingredient, process, technique or innovative method in itself is already approved. The next best thing is that the alternative is in the *light orange* range (22% for EU, 13% for US). This means that it is not approved, but something rather similar is. As a consequence, it is expected that approval is likely and should not be overly burdensome. By contrast, there are only three items in the *red* category (5% for EU). Red is assigned to alternatives, which are banned under the current legal framework of either the EU or the US. This is the case with regard to feeding salmon and shrimp to salmon and shrimp. EU legislation takes a firm stance against cannibalism and this is unlikely to change. The same applies to the EU ban on the use of manure and sludge. Although of course the EU could reconsider the application of this ban to aquaculture. Finally, there are quite a few items in the *grey* range (24% for EU and 31% for US). The grey category reflects that more specific information about the process or technology is required to assess their legality. For instance, some GM terrestrial plants are approved both in the EU and the US and able to enter the market, while others may not. This is why it is important to specify which terrestrial plants are considered as alternative feed. So a grey designation also reflects uncertainty, since designation would be green for approved GM plants and dark orange for non-

approved varieties, given that approval for a GMO under the EU legal framework is difficult to obtain.

One should therefore bare in mind that not only the green and light orange, but also the grey may contain promising alternatives and even the dark orange category may contain others that could well be introduced on the market, provided that one is willing to undertake the effort of obtaining approval.

Annex 1: Ingredient Specific Legislation

This Annex contains the *Ingredient Specific Legislation*, which breaks down for each ingredient why the ingredient was assigned a certain colour, and under which conditions a specific ingredient can enter the EU or US market (labelling, ingredient content percentages, etc.). It is mentioned where the same legal qualification applies to a similar ingredient.

Each section of the Annex has been titled to match:

- First the broad category on sources of ingredients, e.g.: (a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO₂ and energy.
- Second the type of ingredient, e.g.: 1) Protein - processed or concentrated - or starch from locally available food waste stream, and
- Third the actual ingredient itself, e.g. 1. Apple pomace.

It is important to note that broad category (a) - (d) contain items, which fall under the legal definition of feed ingredients. From category (e) onwards, the items constitute various aquaculture processes, technologies, and innovative methods. Legally speaking, this means that other legal regimes than food and feed safety have to be complied with, such as maritime law and state-specific aquaculture regulation. Unfortunately, a significant number of processes are marked “grey” in these categories. Grey symbolizes that no data is available, or that more specific information about the process or technology is required to assess their legality.

Category a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO₂ and energy.

1) Protein (processed or concentrated) or starch from locally available food waste stream (i.e. cassava or whiskey mash)

1. Spent grains, distillers dark grain & draft (ales, lagers & spirits)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Mash filter grains” under 1.12.14, defining them as “Solid product obtained through the production of beer, malt extract and whisky spirit”. It consists of the residues of hot water extraction of ground malt and possibly other sugar or starch-rich adjuncts. Typically marketed in the moist form after the extract has been removed by pressing”.

This ingredient is designated green because it is on the EU Catalogue of Feed Materials. There are even already active EU projects in this area, such as the LIFE-Brewery project (funded by LIFE, the EU’s funding instrument for the environment and climate action).³¹

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists both “Grains” (Barley, corn (organic and genetically modified), oats, rice, sorghum, and wheat) as well as “Processed grain by-products”, which includes distillers products, brewers dried grains, corn gluten, sorghum germ cake and meal, peanut skins, and wheat bran.³² As such this ingredient was green, as it is already approved and can enter the market.

³¹LIFE - Brewery “New Strategies for Improving the Sustainability of Breweries: Full Waste Recovery for Aquaculture Feed” (European Commission, 1 September 2017)
<http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=6266>
accessed 30 November 2018.

³²Sapkota, Amy R., et al. "What do we feed to food-production animals? A review of animal feed ingredients and their potential impacts on human health." *Environmental health perspectives* 115.5 (2007): 663-670.

2. Pomace (apples)

EUROPEAN UNION

Pomace (apples) are not mentioned specifically in Regulation (EC) No 767/2009 or Regulation (EU) 2015/ 2283. However, the EU Catalogue of Feed Materials lists “Apple pulp, dried; [apple pomace, dried/pressed]” under 5.4.1. and 5.4.2, defining it as “Product obtained from the production of juice of *Malus domestica* or cider production. It consists principally of internal pulp and outer skins that are dried. The apple pomace can be either dried or pressed”. As such, this ingredient was designated green, as it is already on the market as an approved feed ingredient, although specific conditions apply.

Specific Conditions:

However, Regulation (EC) No 767/2009 does address fruit and whole fruit, in the following ways, which relate to “Safety and marketing requirements”. Regulation (EC) No 767/2009 - Art 22(1-2). Feed materials and compound feed may be placed on the market only in sealed packages or containers. Packages or containers shall be sealed in such a way that, when the package or container is opened, the seal is damaged and cannot be reused.

Furthermore, Regulation (EC) No 767/2009 – Annex I(2) entails that the botanical purity of feed materials shall not be less than 95%, unless a different level has been laid down in the EU Catalogue. Botanical impurities comprise impurities of plant materials that do not have adverse effects on the animals e.g. straw and seeds of other cultivated species or weeds. Botanical impurities such as residues of other oil seeds or oil fruits derived from a previous manufacturing process, shall not exceed 0,5 % for each type of oil seed or fruit.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists clearly “Fruit and fruit by-products”, which include dried citrus pulp, apple pomace, and pectin pulp. As such this ingredient was designated green, as it is already on the market as an approved feed ingredient.

3. Whey, whey concentrate and whey permeate (cheese)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists a variety of way products under 8.18.1 - 8.22.1, with Whey Concentrate listed specifically under number 8.22.1. Therefore, this ingredient was designated green, as it is already on the market as an approved feed ingredient.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Dairy products”, under which it includes dried cow milk, casein, whey products, and dried cheese. As such this ingredient was given a green marking, as it is already on the market as an approved feed ingredient.

4. Egg shell waste (shell)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Egg shells, dried” under 9.15.5 in Part 3 of the Annex, defining the ingredient as “Product obtained from poultry eggs, after the content (yolk and albumen) has been removed. Shells are dried”. It is important to note that shells must be dry in order to comply.

Therefore, this ingredient was designated green on the market as an approved feed ingredient.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Rendered animal protein from the slaughter of food”, the definition of which includes “egg-shell”. As such this ingredient was designated green, as it is already on the market as an approved feed ingredient.

5. Pomace (skin and seeds) (light wines)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists various types of pomace which can be used in feed, including “Apple pulp, dried; [apple pomace, dried]” under 5.4.1, “Apple pulp, pressed; [apple pomace, pressed]” under 5.4.2, “Tomato pulp [tomato pomace]” under 5.35.1, and “Lucerne pomace; [alfalfa pomace]” under 6.10.6.

As such, it can be understood that pomace (skin and seeds) are approved feed ingredients, however there is no mention in the catalogue or in the regulations of “light wines”. Therefore, the ingredient was marked as light orange, even though the Catalogue is very open to variants of pomace.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds clearly list “Fruit and fruit by-products”, which include dried citrus pulp, apple pomace, and pectin pulp. As such this ingredient was designated green, as it is already on the market as an approved feed ingredient.

6. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Citrus pulp” under 5.13.1, defining it as “Product obtained by pressing citrus fruits *Citrus* (L.) spp. or during the production of citrus juice. It may have been depectinised”. This definition includes oranges and their extracts: peel, seed, and membrane residue. Therefore, this ingredient was designated green as it is already on the market as an approved feed ingredient.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Fruit and fruit by-products”. As such this ingredient was designated green, as it is already on the market as an approved feed ingredient.

7. Fibre, concentrated fruit juice, protein from potato starch, potato protein concentrate

EUROPEAN UNION

The EU Catalogue of Feed Materials lists various concentrate fruit juices (fruit pulp, apple juice, citrus juice, grape juice, tomato juice, Lucerne juice, among others). More specifically the Catalogue also lists “Potato juice, concentrated” under 4.8.14, and defines it “Concentrated product of the manufacture of potato starch, consisting of the remaining substance after the partial removal of fibre, proteins and starch from the whole potato pulp and evaporation of part of the water.” This definition definitely includes the given ingredient, therefore it was marked green.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists both “Plant protein products” and “Fruit and fruit by-products”, as well as “Molasses”, the definition of which includes “starch”. Looking at the combination of these definitions, it is safe to assume that this ingredient can be marked as green.

8. Peelings (potatoes)

EUROPEAN UNION

EU Catalogue of Feed Materials lists both “Potato peelings, steamed” under 4.8.3 and “Potato scrapings” under 4.8.5, defining the former as “Moist product from the potato processing industry consisting of the peelings removed by steam treatment from the potato tuber to which auxiliary flows of gelatinous potato starch may be added. It may be mashed”. It is also interesting to note that other peelings are also listed in the Catalogue, meaning that the whole category of “peelings” (not just those of potatoes) can be marked as green.

UNITED STATES

The AAFCO data that the project had access to did not include potato peelings specifically. However, the previously reviewed definitions included starch products, plant protein products and various by-products thereof. As such, the ingredient was marked green.

9. Organic wastes, mash from grain, fruit or potato (spirits)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Distillers’ grains and solubles” under 1.12.9, defining them as “Product obtained when producing alcohol by fermentation and distilling grain mash of cereals and/or other starchy and sugar containing products. They may contain dead cells and/or parts of the fermentation micro-organisms”. This ingredient is marked green as the given definition includes organic wastes of mash from grain (spirits), even though it does not specifically mention mash from fruit or potato.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists include various definitions which mash from grain, fruit or potato falls under. Including but not limited to “Processed grain by-products”, “Fruit and fruit by-products”, “Molasses” and “Miscellaneous”. Therefore, this ingredient is marked green.

10. Sugar beet pulp

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Wet (sugar) beet pulp” (4.1.7), “Pressed (sugar) beet pulp” (4.1.8), “Pressed (sugar) beet pulp, molassed” (4.1.9), “Dried (sugar) beet pulp” (4.1.10) and “Dried (sugar) beet pulp, molassed” (4.1.11). As such, it suffices to say that this ingredient certainly needs to be marked green.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Molasses”, under the definition of which it is further specified that this includes beet molasses, or beet pulp. As such this ingredient was given a green marking, as it is already on the market as an approved feed ingredient.

11. Pomace (skin, pulp & seeds) (tomatões)

EUROPEAN UNION

Various forms of pomace are approved under the current EU legislative framework, see sections 5 and 10 of this report. As such, this ingredient was also marked green.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Molasses”, under the definition of which are listed several examples of molasses and pulps. As such this ingredient was given a green marking, as it is already on the market as an approved feed ingredient.

12. Crude & extracted press cake or spent meal (vegetable oils/margarines)

EUROPEAN UNION

The EU Catalogue of Feed Materials does not specifically list “Crude and extracted press cake or spent meal” or “Margarines” in any combination of those words. However, it does list “Vegetable oil and fat” under 2.20.1, defining it as “Oil and fat obtained from plants (excluding castor oil from the ricinus plant), it may be degummed, refined and/or hydrogenated”. As such, this ingredient was marked light orange, to indicate that even though an ingredient from its category is approved under EU law the specifications for the particular ingredient itself still need to be independently clarified.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Plant protein products” defining them as “Canola meal, cottonseed cakes and meals, peanut meal, safflower meal, and soybean (organic and genetically modified) feed and meal”. As well as listing “Processed grain by-products”, defining them as “Distillers products, brewers dried grains, corn gluten, sorghum germ cake and meal, peanut skins, and wheat bran”. The ingredient at hand falls under a combination of these ingredients, therefore it can be marked as green.

13. Olive stones (vegetable oil)

EUROPEAN UNION

The EU Catalogue of Feed Materials does not specifically list “olive stones”, however it does list “Defatted olive meal feed” under 2.11.2, which it defines as “Product of olive oil manufacture, obtained by extraction and appropriate heat treatment of olive pulp expeller separated as far as possible from parts of the kernel. May contain up to 1 % used bleaching earth and filter aid (e.g. diatomaceous earth, amorphous silicates and silica, phyllosilicates and cellulosic or wood fibres) and crude lecithin from integrated crushing and refining plants”.

Furthermore, the Catalogue lists “Vegetable oil and fat” under 2.20.1, defining it as “Oil and fat obtained from plants (excluding castor oil from the ricinus plant), it may be degummed, refined and/or hydrogenated”. These two definitions definitely cover the given ingredient. As such this ingredient was given a green marking, as it is already on the market as an approved feed ingredient..

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Fats and oils”, the definition of which includes “Animal fat, vegetable fat or oil, and hydrolyzed fats”. As such this ingredient was given a green marking, as it is already approved and can enter the market.

14. Wheat feed / wheat middlings (wheat milling products)

EUROPEAN UNION

The EU Catalogue of Feed Materials lists “Wheat Feed” under 1.11.6, defining it as “Product of flour or malting manufacture obtained from screened grains of wheat or dehusked spelt. It consists principally of fragments of the outer skins and of particles of grain from which less of the endosperm has been removed than in wheat bran”. Furthermore, it lists “Wheat middlings” under 1.11.4, defining it as “Product of flour manufacture obtained from screened grains of wheat or dehusked spelt. It consists principally of particles of endosperm with fine fragments of the outer skins and some grain

screenings”. These two definitions certainly include the given ingredient. Therefore, this ingredient was marked green.

UNITED STATES

Data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists “Grains”, the definition of which includes wheat and wheat feed. As such this ingredient was given a green marking.

15. Other innovations

No data – as it is not possible to assess the legal conditions of an unknown protein.

1a) Wild Cards

a) Land animal proteins resulting from by-products of food industry

EUROPEAN UNION

Most importantly, a key principle of EU feed law seeks to prevent intraspecies cannibalism. This principle is enshrined in several legal documents, including Regulation 1069/2009 (Animal by-products Regulation). Article 11(d) of this regulation, on restricted use, states that “the feeding of farmed fish with processed animal protein derived from the bodies or parts of bodies of farmed fish of the same species” shall be prohibited. Thus, in the use of any ingredients resulting from by-products of the food industry in feed must be approached with great caution, to ensure that this principle of restricted use is abided by.

So long as this principle is respected, the EU Catalogue of Feed Materials does list various kinds of “Animal by-products”, defining them in section 9.1.1 as “Whole or parts of warm-blooded land animals, fresh, frozen, cooked, acid treated or dried.”

Furthermore sections 13.1.11 to 13.1.14 list several kinds of by-products from the food industry, including “Products and by-products of the sauces production”, “Products and by-products from the savoury snacks industry”, and “Products from the ready-to-eat food industry”.

To go even further the catalogue includes “Catering Reflux”, defined as “All waste food containing material of animal origin including used cooking oil originating in restaurants, catering facilities and kitchens, including central kitchens and household kitchens”.

As such, this ingredient is given the green marking, provided that conditions of food safety and secured sourcing are met, as well as that Article 11 of Regulation 1069/2009 is respected.

UNITED STATES

The data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists, and therefore approves as safe and attainable, both “Restaurant food waste” and “Miscellaneous”. “Restaurant food waste” is defined as “Edible food waste from restaurants, bakeries, and cafeterias”, while “Miscellaneous” is defined as “Almond hulls and ground shells, buckwheat hulls, legumes and their by-products, and other crop by-products”. As such, this ingredient has been marked green.

1b) Land Animal Protein

EUROPEAN UNION

In Europe, the use of processed animal proteins (PAPs) in fish feeds used to be prohibited, but regulatory changes enforced in June 2013 opened up the European aquaculture sector to this protein source.³³

This is confirmed in the EU Catalogue of Feed Materials, which lists all of the following:

In section 9.2.1 “Animal Fat”, defined as “product composed of fat from land animals, including invertebrates other than species pathogenic to humans and animals in all their life stages. If extracted with solvents, may contain up to 0,1 % hexane.”

In section 9.4.1 “Processed Animal Protein”, defined as “product obtained by heating, drying and grinding whole or parts of land animals, including invertebrates other than species pathogenic to humans and animals in all their life stages from which the fat may have been partially extracted or physically removed. If extracted with solvents, may contain up to 0,1 % hexane.” **It is important to note that this definition includes processed protein from insects** (as clarified in amendment 34).

In section 9.5.1 “Gelatine process derived proteins”, defined as “dried animal proteins derived from the production of gelatine obtained from raw materials pursuant to Regulation (EC) No 853/2004.”

In section 9.7.1 “Blood meal”, defined as “product derived from the heat treatment of blood of slaughtered warm-blooded animals”, and in section 9.8.1 “Blood products”, defined as “products derived from blood or fractions of blood of slaughtered warm-blooded animals; they include dried/frozen/liquid plasma, dried whole blood, dried/frozen/liquid red cells or fractions thereof and mixtures”. As such, this ingredient was marked green.

UNITED STATES

According to the CFR, §589.2000 the use of animal protein is only prohibited in ruminant feed. To confirm this: data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feeds lists all of the following:

“Rendered animal protein from the slaughter of food production animals and other animals”, defined as “meat meal, meat meal tankage, meat and bone meal, poultry meal, animal by-product meal, dried animal blood, blood meal, feather meal, egg-shell meal, hydrolysed whole poultry, hydrolysed hair, bone marrow, and animal digest from dead, dying, diseased, or disabled animals including deer and elk”.

“Animal waste”, defined as “dried ruminant waste, dried swine waste, dried poultry litter, and undried processed animal waste products”. As such, this ingredient was marked green.

2) Protein from Insects fed on Food waste and/or food industry coproducts

EUROPEAN UNION

Prior to July 2017 EU legislation effectively prohibited the feeding of processed animal proteins to animals intended for human consumption, as a product of caution from the BSE crises.³⁴ As consequence of the crisis EU legislation, namely Regulation (EC) No 999/2001 (the TSE Regulation), prohibited insect derived proteins from use in pig or poultry feed.³⁵ The regulation used to apply to aquaculture feed as well as pig and poultry feed, but on July 2017 and exception was made and insect

³³ Karapanagiotidis, I. T. (2014). The re-authorization of non-ruminant processed animal proteins in European aqua feeds.

³⁴ Ibid.

³⁵ Regulation (EC) No 999/2001 laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies (TSE Regulation).

meal is now permitted as an ingredient in aquaculture feed.³⁶ The creation of the exception was the result of a scientific opinion by the European Food Safety Authority (EFSA), which concluded that the ‘possible occurrence of microbiological hazards in insect protein sources is expected to be comparable to their occurrence in other non-processed sources of protein of animal origin’.³⁷

The recently adopted Regulation No 2017/893 indeed authorises the use of insect proteins originating from seven insect species – namely Black Soldier Fly (*Hermetia illucens*), Common Housefly (*Musca domestica*), Yellow Mealworm (*Tenebrio molitor*), Lesser Mealworm (*Alphitobius diaperinus*), House Cricket (*Acheta domesticus*), Banded Cricket (*Gryllodes sigillatus*) and Field Cricket (*Gryllus assimilis*) – in feed for aquaculture animals. The regulation was adopted by the European Commission on the 24th of May 2017, and the text entered into force on the 1st July 2017.³⁸ Relevant amendments were also made Regulation No 142/2011, most notably Annex X, chapter II section 1.

Of the species listed by the Feed X nutritional lens (Black soldier fly, Common Housefly, House Cricket, and silkworm), two were given the marking green and one the marking light orange. The different species of fly and cricket were given the marking green as they are all specifically listed as approved for market entry. The “Silkworm pupae meal” was given the marking light orange, as that specific ingredient has not been approved, but similar ingredients (Yellow Mealworm and Lesser Mealworm) are already approved.

These amendments are a significant step for insects as ingredients in animals feed. While the EU’s Novel food regulations allow whole insects to be sold on the shelves of the supermarket, these new amendments also allow proteins and fats extracted from insects to be used in feed. The breakthrough is, however, subject to specific conditions which are outline below.

First, compliance with the EU package of legislative texts which define general principles and standards in the area of food and feed safety. These include the ‘General Food Law’ (Regulation No 178/2002), and the ‘Hygiene Package’ (e.g. Regulation No 852/2004 on the hygiene of foodstuffs and Regulation No 183/2005 laying down requirements for feed hygiene).³⁹ According to these Regulations, producers of insects – like any other food or feed business operator – are responsible for ensuring the safety of the marketed products.⁴⁰ These Regulations impose general obligations on those actors – such as the registration or approval of their activities before national competent authorities – and establish hygiene standards to be applied at the different stages of production covered. Furthermore, Regulation 853/2004 includes the requirements on the hygiene of specific types of animal origin-foods. These rules are placed in Annex III, sections I-XIV. A separate hygiene rule section is expected for insects.⁴¹

Second, compliance with requirements on how to keep and feed insects bred for feed purposes. Insects are considered farmed animals and therefore they can be fed with all the type of feed

³⁶ Rachel O'Connor “Insect meal in aquaculture – a move towards sustainable protein in animal feed?” (Michelmores, 24 October 2017) <<https://www.michelmores.com/news-views/news/insect-meal-aquaculture>> accessed 10 December 2018.

³⁷ EFSA ‘s opinion: ‘risk profile related to production and consumption of insects as food and feed’ (8 October 2015)

³⁸ Regulation (EU) No 2017/893 amending Annexes I and IV to Regulation (EC) No 999/2001(see notably Annex IV, section F) and Annexes X, XIV and XV to Regulation (EU) No 142/2011 (see notably Annex X, chapter II section 1.

³⁹ International Platform of Insects for Food and Feed “EU Legislation” (IPIFF, 2018). Accessed 11 January 2019 <<http://ipiff.org/insects-eu-legislation/>>

⁴⁰ Ibid.

⁴¹ Lahteenmaki-Uutela, A., Grmelová, N., Hénault-Ethier, L., Deschamps, M. H., Vandenberg, G. W., Zhao, A., & Nemane, V. (2017). Insects as Food and Feed: Laws of the European Union, United States, Canada, Mexico, Australia, and China. *Eur. Food & Feed L. Rev.*, 22.

approved at EU level. Obligations lie with insect producers to ensure that their animals are kept in good health, to prevent the spread of diseases, as outlined in ‘EU Animal Health Law’.⁴²

Third, animal welfare are absent. In this area, EU policy makers have left out invertebrate animals, which include insects, from the scope of the EU animal welfare legislation that normally apply to European animal breeders.⁴³ This means that today’s insect producers are exempted from any EU legal obligations in the area of animal welfare, as outlined in Article 1(d) of Directive 98/58 concerning the protection of animals kept for farming purposes.

UNITED STATES

Edible insects are considered food additives in the United States, but there is a complete lack of federal rules on insect food and feed, causing much confusion at the state level.⁴⁴ A 2017 study published in the European Food & Feed Law Review found the following:

“local inspectors may close down an insect production facility or an insect restaurant, if ingredients are not from an FDA-approved source. The attitudes of health departments vary from city to city with some more accepting of insects as food than others. At the moment, approved insect sources may be difficult to find.”

As such, this ingredient was marked as grey, due to such unclear market access circumstances. Regarding the specific circumstances, there are no federal rules on the use of insects as feed ingredients. However, there are federal rules which set specific conditions for labelling of food products which contain insects. Namely, all insect products must be labelled with both the common and scientific name and a potential shellfish allergy warning must be on the packaging for the product.⁴⁵ These rules do not apply to fish/shellfish fed on insects.

3) Protein from fermentation on processes using waste streams

3a) Microbial - Sustainable CO2 source, Bio-gas"

Bacteria (Methanomonas)

EUROPEAN UNION

The EU Catalogue of Feed Materials does not list the given species of Bacteria (Methanomonas), but it does list “Bacterial protein from Escherichia coli” and “Bacterial protein from Corynebacterium glutamicum”, which are a species of bacteria.

As such this ingredient is given the light orange marking as an ingredient in the same category is approved but the ingredient itself is only on the radar of the targeted market.

UNITED STATES

The FDA’s “Food Additive Status List” formerly called Appendix A of the Investigations Operations Manual (IOM), organizes additives found in many parts of 21 CFR into one alphabetized list.⁴⁶ These additives are considered safe, and therefore approved for market access.

The said list lists various kinds of bacteria and bacterial by-products. Including, but not limited to: “Bacteria (harmless, lactic acid producing; propionic acid producing)”, “Bacterial Catalase”, and “Micrococcus lysodeikticus”. As such, this ingredient was marked green.

⁴² EU Animal Health Law – Regulation (EU) No 2016/429 on transmissible animal diseases

⁴³ International Platform of Insects for Food and Feed “EU Legislation” (IPIFF, 2018). Accessed 11 January 2019 <<http://ipiff.org/insects-eu-legislation/>>

⁴⁴ Ibid, 25.

⁴⁵ FAO discussion paper: Regulatory frameworks influencing insects as food and feed, 2014, p. 30.

⁴⁶ FDA “Food Additive Status List” (FDA Website, 1 April 2018), <<https://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm091048.htm>> accessed 1 December 2018.

Microalgae (Spirulina Arthospira or Chlorella)

EUROPEAN UNION

The EU Catalogue on Feed Materials lists various types of algae and seaweed, under sections: 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5 and 7.1.6. Therefore, this ingredient is given the green marking as the ingredient is approved.

UNITED STATES

Even though “Microalgae (Spirulina Arthospira or Chlorella)” are not mentioned specifically, the FDA’s Food Additive Status List lists both “Algae, brown (kelp), or red” and “Kelp (see algae, brown)”. As such, this ingredient is marked as green.

3b) Food waste or food industry co-product (sugars)

Single cell proteins (SCP)

EUROPEAN UNION

There is not enough clarity provided on which single cell proteins specifically would be used as the novel ingredient. Therefore, there is not enough information to provide a conclusive evaluation of the conditions under which the ingredient is or can be legally approved for market access.

Furthermore, the e-mail interview with a Skretting legal representative provided the information that Skretting generally struggles to get specific strains of single cell protein bacteria out on the market, because all the specific strains are not registered with the EU. Therefore, this ingredient is marked grey.⁴⁷

UNITED STATES

A legal assessment requires further information, same as the EU section on this ingredient. Therefore, it is marked grey.

Heterotrophic Algae

The nutritional Feed X lens defines “Heterotrophic microalgae” as algae grown on renewable sugar from sugarcane, producing a highly sustainable source of protein. TerraVia is focused on using Brazilian sugarcane and dextrose derived from U.S. corn (TerraVia uses proprietary technology to transform a range of low-cost plant-based sugars into high-value oils and whole algae ingredients).

EUROPEAN UNION

The EU Catalogue on Feed Materials lists various types of algae and seaweed, under sections: 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5 and 7.1.6. Therefore, this ingredient is given the green marking as the ingredient is approved.

UNITED STATES

Even though heterotrophic algae is not mentioned specifically, the FDA’s Food Additive Status List lists both “Algae, brown (kelp), or red” and “Kelp (see algae, brown)”. As such, this ingredient is marked as green.

Yeast

EUROPEAN UNION

The EU Catalogue of Feed Materials lists various kinds of yeast:

⁴⁷ Answer to Interview question from a Skretting legal representative.

“Wheat yeast concentrate” under 1.11.22, which is defined as “Wet by-product that is released after the fermentation of wheat starch for alcohol production”. “Grain protein concentrate” under 1.12.3, defined as “Concentrate and dried product obtained from grain after starch removing through yeast fermentation”.

“Yeasts and parts thereof [brewers’ yeast] [yeast product” under 12.1.5, which is defined as “All yeasts and parts thereof obtained from *Saccharomyces cerevisiae*, *Saccharomyces carlsbergensis*, *Kluyveromyces lactis*, *Kluyveromyces fragilis*, *Torulasporea delbrueckii*, *Candida utilis*/*Pichia jadinii*, *Saccharomyces uvarum*, *Saccharomyces ludwigii* or *Brettanomyces* ssp. (1) (2) on substrates mostly of vegetable origin such as molasses, sugar syrup, alcohol, distillery residues, cereals and products containing starch, fruit juice, whey, lactic acid, sugar, hydrolysed vegetable fibres and fermentation nutrients such as ammonia or mineral salts.”

“Yeasts from biodiesel process” under 12.1.7, which is defined as “All yeasts and parts thereof obtained from *Yarrowia lipolytica* (1) (2) grown on vegetable oils and degumming and glycerol fractions formed during biofuel production.”

Most of these definitions include the crude protein. Therefore, yeast was marked as green.

UNITED STATES

The data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feed lists “Direct-fed organisms”, defined as “*Aspergillus niger*, *Bacillus subtilis*, *Bifidobacterium animalis*, *Enterococcus faecium*, and **yeast**”. Furthermore, the FDA’s Food Additive Status List lists an abundance of different types of yeast, including “Bakers Yeast Protein”, “beet sugar & yeast”, “yeast-leavened bakery products”, etc. As such, this ingredient was marked as green.

Fungi

EUROPEAN UNION

In this instance, the definition by the nutritional lens of Feed X is specifically focused on fungi that grow on sugar. Regulation (EC) No 767/2009 mentions fungi in Art.3 (2(a)) which defines ‘novel food’ as any food that was not used for human consumption to a significant degree within the Union before 15 May 1997, irrespective of the dates of accession of Member States to the Union, and that falls under at least one of several categories, one of which is “food consisting of, isolated from or produced from microorganisms, fungi or algae” (ii) and “food consisting of, isolated from or produced from cell culture or tissue culture derived from animals, plants, micro-organisms, fungi or algae”. As such, the ingredient is marked as green.

UNITED STATES

Neither the available AAFCO data nor the Food Additive Status List include the word “fungi” specifically. However, an abundance of Microorganisms & Microbial-Derived Ingredients are on these lists as approved feed ingredients. As such, this ingredient has been given the light orange marking, as an ingredient in the same category is approved but the ingredient itself is not.

3c) Waste product such as: Cellulose

Fungi that grows on cellulose

The nutritional lens of Feed X is interested in: "An edible microfungi (zygomycetes) for having potential as protein feed (high CP) for salmon and shrimp. The chitosan-rich cell wall of these fungi make them interesting for fish and animal feed (Taherzadeh 2012). Decomposed dead plant material (Cewatech).

EUROPEAN UNION & UNITED STATES

The distinction between fungi grown on sugar and fungi grown on cellulose is not relevant from a legal perspective, so this fungi is marked as green for the EU and light orange for the U.S., applying the same reasoning as the fungi in the category above.

4)Protein from using energy waste like CO₂, natural gas

Energy waste from sludge gas

EUROPEAN UNION

Regulation (EC) No 767/2009, ANNEX III includes “sludge” in its list of materials whose placing on the market or use for animal nutritional purposes is restricted or prohibited as referred to in Article 6. The ingredient is included in Chapter 1(5), where it is stated that:

- “All waste obtained from the various phases of the urban, domestic and industrial waste water as defined in Article 2 of Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (2), irrespective of any further processing of such waste and irrespective also of the origin of the water.”

Article 2 of the Council Directive 91/271/EEC includes “sludge”. Therefore, sludge is given the marking red.

UNITED STATES

The data adopted from the AAFCO on animal feed ingredients that are legally used according to the U.S. animal feed lists include “Animal waste”, defined as “Dried ruminant waste, dried swine waste, dried poultry litter, and undried processed animal waste products”. Furthermore, it lists “Contaminated/adulterated food”, defined as “Food adulterated with rodent, roach, or bird excreta that has been heat treated to destroy pathogenic organisms”. As such, this ingredient was marked green.

Energy waste from manure

EUROPEAN UNION

In its Annex III list of materials whose placing on the market or use for animal nutritional purposes is restricted or prohibited, in Regulation (EC) No 767/2009 includes in Chapter 1(1): “Faeces, urine and separated digestive tract content resulting from the emptying or removal of digestive tract, irrespective of any form of treatment or admixture.” Furthermore, digestive tract waste cannot be used under any circumstances, irrespective of any form of treatment or admixture - according to the Annex III list of materials whose placing on the market or use for animal nutritional purposes is restricted or prohibited, in Regulation (EC) No 767/2009.

Therefore, manure is given the marking red.

UNITED STATES

The data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feed lists “Animal waste”, defined as “Dried ruminant waste, dried swine waste, dried poultry litter, and undried processed animal waste products”. As such, this ingredient was marked green.

Use of waste heat for flocculation of proteins from waste streams (e.g. effluent)

In this instance, the Feed X project idea behind this ingredient is that during the filleting of fish the product or its co products are intensively in contact with water. In order to clean the product or the process line. During this water soluble proteins solubilize in this water. The proteins in the solution could be precipitated by the use of “waste” heat and collected again as a protein source.

EUROPEAN UNION

As both various types of protein and food-industry by-products have been approved for introduction as feed ingredients on the market, it would follow that waste heat for flocculation of proteins from waste streams would also be approvable. Further research is needed for exact specification. However, this practise seems to risk feeding to a species its own kind, something which is strictly forbidden under the EU legal framework to counter animal health risks, as defined in Article 11(d) or Regulation 1069/2009 on Animal by-products. Therefore, the colour marking red has been chosen.

UNITED STATES

As both various types of protein and food-industry by-products have been approved for use as feed ingredients, it would follow that waste heat for flocculation of proteins from waste streams could also be approved. The prohibition of feeding a species its own kind does not apply in the US. It is likely that this item can be marked green or light orange, but given that further research is needed for exact specification, it is marked grey.

Category b) Nutritional solutions creating health effects equal to or greater than fatty acids (e.g. DHA-EPA)

5) Non-marine (non-animal) oil sources of Omega-3

Bacteria

Same answer as the Bacteria under 3a) of this report, or V5 in the table.

Seaweed

EUROPEAN UNION

The EU Catalogue on Feed Materials lists “Seaweed meal” under 7.2.6, and defines it as “Product obtained by drying and crushing macro-algae, in particular brown seaweed. This product may have been washed to reduce the iodine content. May contain up to 0,1 % of antifoaming agents.”

The ingredient can be placed on the market provided that it meets the conditions set forth in Article 4 of Regulation 767/2009, according to which "feed may only be placed on the market and used if: (a) it is safe; and (b) it does not have a direct adverse effect on the environment or animal welfare".

Therefore, this ingredient is given the marking green.

UNITED STATES

Neither the available AAFCO data nor the Food Additive Status List include the word “Seaweed”. However, since various types of algae are approved as safe and attainable, it would follow that seaweed would be attainable also. As such, the green marking was given.

Microalgae

EUROPEAN UNION

The EU Catalogue on Feed Materials lists various types of algae and seaweed, under sections: 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5 and 7.1.6. Therefore, this ingredient is given the green marking as the ingredient is approved.

UNITED STATES

Neither the available AAFCO data nor the Food Additive Status List include the word “Microalgae”. However, since various other types of algae are approved as safe and approved to be introduced on the market, it would follow that microalgae could obtain approval as well. As such, the ingredient was given a light orange marking.

GM terrestrial plants

EUROPEAN UNION

Regulation (EC) 1829/2003 of the European Parliament and of the Council on genetically modified food and feed was adopted on 22 September 2003. For feed, the Regulation establishes criteria for evaluating the potential risks, harmonized procedures for risk assessment and authorization as well as provisions for the labelling of feed consisting of and containing GMOs and produced from GMOs.

The wording of this ingredient is too broad to be pinned down specifically from a legal perspective. Some GM terrestrial plants may be approved and able to enter the market while others may not. This is why it is important to specify particularly which terrestrial plants the study refers to. For instance the EU register of genetically modified food and feed does include “Genetically modified sugar beet that expresses: a CP4 EPSPS protein confers tolerance to glyphosate containing herbicides” as an approved ingredient. Therefore, if the plant referred to was this particular GM sugar beet, this would be an approved ingredient. As such, this ingredient was given the marking grey because further specification is needed as to which GM plants it specifically refers to. It would be green for approved GM plants and dark orange for non-approved varieties, given that approval for a GMO under the EU legal framework is difficult to obtain.

Specific conditions: GMO food and feed must be labelled: the list of ingredients must indicate "genetically modified" or "produced from genetically modified [name of the organism]". For products without packaging, these words must be clearly displayed in close proximity to the product. The labelling requirements do not apply if the food or feed ingredients considered individually contain max 0.9 % GMO and this presence is adventitious or technically unavoidable.⁴⁸ It is important to note that the EU labelling requirements do not apply on food from animal origin which was fed GMO's. Therefore, it will not appear on the label if salmon or shrimp was fed GMO's. This differs from the ASC label requirements, which demand that buyers are informed whether farmed salmon has been fed on GMO (transgenic) plants or raw materials derived from transgenic plants.

UNITED STATES

The existing FDA safety requirements impose a clear legal duty on everyone in food industry process to contribute to market safety of foods. It is unlawful to produce, process, store, ship or sell to consumers unsafe foods.⁴⁹ The FDA's role is to ensure that everyone in the farm to table continuum is meeting this obligation. As such, to ensure this requirement is complied with in relation to GM foods the FDA created the Plant Biotechnology Consultation Program in the 1990's to cooperatively work with GE plant developers in helping them ensure foods made from their new GE plant varieties are safe and lawful. In this program, the safety of food and feed from new GE crops is evaluated before entering the market.⁵⁰

Similarly to the remarks about GM feed in the EU, this item requires more specification under the U.S. system as well - before concrete findings can be confirmed. The U.S. does have “Biotechnology Consultations on Food from GE Plant Varieties”,⁵¹ in which it lists the various GM plants which have been approved for use in food and feed. These include various types of GM corn, cotton, apples, pineapple, soybean, etc. As such, this ingredient has been marked as grey, given that the result may vary for different types of GM terrestrial plants as not all varieties are approved).

⁴⁸ Lahteenmaki-Uutela (2017), 22.

⁴⁹ FDA, “How FDA Regulates Food from Genetically Engineered Plants” (FDA Website, 1 April 2018) <<https://www.fda.gov/Food/IngredientsPackagingLabeling/GEPlants/ucm461831.htm>> accessed 15 December 2018.

⁵⁰ Ibid.

⁵¹ FDA, Biotechnology Consultations on Food from GE Plant Varieties, 17 December 2018. <<https://www.accessdata.fda.gov/scripts/fdcc/?set=Biocon>> accessed 15 December 2018.

Category c) Nutritional solutions using inputs that create environmentally restorative effects (e.g. ecosystem rehabilitation)

6) Protein from seaweeds (process or concentrated)

EUROPEAN UNION

The EU Catalogue on Feed Materials lists “Seaweed meal” under 7.2.6, and defines it as “Product obtained by drying and crushing macro-algae, in particular brown seaweed. This product may have been washed to reduce the iodine content. May contain up to 0,1 % of antifoaming agents.”

More importantly here, Regulation (EC) No 767/2009 mentions algae in Art.3 (2(a)) which defines ‘novel food’ as any food that was not used for human consumption to a significant degree within the Union before 15 May 1997, irrespective of the dates of accession of Member States to the Union, and that falls under at least one of several categories, one of which is “food consisting of, isolated from or produced from microorganisms, fungi or **algae**” (ii) and “food consisting of, isolated from or produced from cell culture or tissue culture derived from animals, plants, micro-organisms, fungi or **algae**.”

Therefore, this ingredient is given the green marking as it is already approved.

UNITED STATES

The data adopted from the AAFCO on animal feed ingredients that are legally used in U.S. animal feed lists “Plant protein products”, while the Food Additive Status List lists various kinds of algae. As such, this ingredient has been given the green marking.

7) Protein from insects fed on seaweeds

EUROPEAN UNION

As of 2017, protein from insects (and other land animals) is permitted in the EU, as explained in the section above on Insects. Furthermore, we know that use of various types of algae and seaweed meal as feed ingredients are also permitted under EU legislation, because the EU Catalogue on Feed Materials lists various types of algae and seaweed, under sections: 7.1.1, 7.1.2, 7.1.3, 7.1.4, 7.1.5 and 7.1.6. Therefore, this ingredient is given the green marking as the ingredient is approved.

UNITED STATES

The complete confusion regarding insects as feed ingredients, as explained in the above section on Insects, includes the approval of ingredients fed to insects for consumption in animal feed. As such, this feed ingredient is also marked dark orange, due to such unclear market access circumstances.

Category d) Technology solutions creating net positive effects using renewable energy, packaging waste, energy waste, sustainable transport.

8) Use of solar and wave powder to produce/test feed and ingredients

Pellet extrusion running on solar energy

Due to insufficient information available on the process and its outcomes, assessing the legality of this item requires further research.

Packaging waste recycling or reusing

EUROPEAN UNION

On the 18th of April 2018 the European Parliament approved the package to update current waste management rules, including new targets for recycling, packaging and landfilling. The package is a key element of the Circular Economy Action Plan the European Commission adopted on 2 December 2015.⁵² Landfilling of waste makes no sense in a circular economy and can pollute water, soil and air. By 2035 the amount of municipal waste landfilled must be reduced to 10% or less of the total amount of municipal waste generated.⁵³ Recycling and reuse would contribute to this EU objective.

As such, the conclusions drawn for this item are based on the Directive 94/62/EC on Packaging and Packaging Waste. This Directive covers all packaging placed on the European market and all packaging waste, whether it is used or released at industrial, commercial, office, shop, service, household or any other level, regardless of the material used. Member States should take measures to prevent the formation of packaging waste, and to develop packaging reuse systems reducing their impact on the environment. Including, introducing systems for the return and/or collection of used packaging. As such, this method is approved and certainly on the radar of the European Union, which is why this item was marked green.

Specific Conditions: Of course, the methods are subject to certain conditions outlined in Annex II of the directive, by which Member States must ensure that packaging placed on the market complies to:

- limit the weight and volume of packaging to a minimum in order meet the required level of safety, hygiene and acceptability for consumers;
- reduce the content of hazardous substances and materials in the packaging material and its components; to design reusable or recoverable packaging.

UNITED STATES

In August 2006 the FDA released a “Guidance for Industry: Use of Recycled Plastics in Food Packaging”, containing non-binding recommendations. While the document contains many guidelines on various stages of the recycling process, exposure to chemical contaminants, use of effective barriers, and other detailed procedural instructions it certainly does not ban or severely restrict the recycling and re-use of packaging waste. As such, this process has been marked green.

Packaging free feed

EUROPEAN UNION

Packaging free feed was not found to be specifically mentioned in either the Directive 94/62/EC or in any of the relevant accompanying EU projects. However, it can be seen as heavily linked to the category of “Packaging waste recycling or reusing” (discussed above).

As such, the process was marked light orange, to indicate that a process in the same category is approved but the process itself is only on the radar of the targeted market.

UNITED STATES

Packaging free feed was not found to be specifically mentioned in any relevant FDA regulations or recommendation documents. However, it can be seen as heavily linked to the category of “Packaging waste recycling or reusing” (discussed above).

⁵² European Commission Press Release “New waste rules will make EU global front-runner in waste management and recycling” (European Commission, 18 April 2018) <https://ec.europa.eu/info/news/new-waste-rules-will-make-eu-global-front-runner-waste-management-and-recycling-2018-apr-18_en> accessed 10 December 2018.

⁵³ Ibid.

As such, the process was marked light orange, to indicate that a process in the same category is approved but the process itself is only on the radar of the targeted market.

Mapping of local food waste streams to be used in local farms

EUROPEAN UNION

As of 2017, when the last Commission Report on this topic was made available, a brief state of play was presented regarding the Commission's proposal to amend the Waste Framework Directive.⁵⁴ While the Council document did not envisage specific actions in the field of food waste, the European Parliament proposed more ambitious measures, among which: a definition of food waste, an aspirational EU food waste reduction target of 50% by 2030 and the establishment of a food waste hierarchy. Last but not least, the European Parliament also proposed a revision clause that required the Commission to set binding EU food waste targets.⁵⁵

Mapping of local food waste streams to be used in local farms was not specifically mentioned, but the that is because those are measures which could perhaps be better envisioned and performed at the local level. The legislation in this area can only support such initiatives at a procedural level, by setting targets for instance. However, the substantive set-up of such initiative is left to the member states, and specifically regions of the Member States independently.

As such, the process was marked light orange, to indicate that a process in the same category is approved but the process itself is only on the radar of the targeted market.

UNITED STATES

At the federal level there was little to be found on mapping of local food waste streams to be used in local farms, but perhaps that's because this is really a local issue which will vary from state to state. In fact, at the state level there are some active projects in this area, such as the "Local Foods Resource Mapping Project", discussed in the *Arkansas Local Food Meetups Regional Findings Report*⁵⁶ and the 2016 "New England Food Recovery Challenge"⁵⁷. It is evident that this process is being actively pursued at the local state level. As such, this process was marked green.

Category e) Technology solutions increasing the health, survival and growth performance of the fish/shrimp

9) Alternative technology

Extrusion

Due to insufficient information available on the process and its outcomes, assessing the legality of this item requires further research.

⁵⁴ European Commission "EU actions against food waste" (EC Website, 10 December 2018) <https://ec.europa.eu/food/safety/food_waste/eu_actions_en> accessed 10 December 2018.

⁵⁵ Ibid.

⁵⁶ Arkansas Local Food Meetups Regional Findings Report "Local Foods Resource Mapping Project" (University of Arkansas System, June 2017) <<https://www.uaex.edu/business-communities/local-foods/Arkansas%20LFRM%20Project%20Meetup%20Report%20June%202017.pdf>> accessed 10 December 2018.

⁵⁷ EPA "Wasted Food Programs and Resources Across the United States" (EPA Website, 10 December 2018) <<https://www.epa.gov/sustainable-management-food/wasted-food-programs-and-resources-across-united-states>> accessed 10 December 2018.

Category f) Integrated information systems solutions increasing feed waste efficiencies

10) Integrated technologies incorporating digital monitoring to increase the health, survival and growth performance of the fish/shrimp (i.e. including digital health control, A.I. biomass control)

Biosensor (habitat level), to monitor growth, disease, stress, death, population

EUROPEAN UNION

In Regulation 710/2009, Art 25f(2) and (3) call for controls on condition of farmed fish (such as fin damage, other injuries, growth rate, behaviour expressed and overall health) as well as monitoring of the water quality.

As such, this process is given a light orange marking as a process in the same category is approved but the process itself is only possibly on the radar of the regulator.

UNITED STATES

No rules were found to enable an assessment of the legality of this item. It is therefore marked as grey.

Vaccines and alternatives for antibiotics (i.e. natural practices, probiotics, etc)

EUROPEAN UNION

The use of antibiotics in European aquaculture has decreased markedly in the past decade, mostly due to the development of vaccines. This trend should be further encouraged, and the development of new vaccines is a research priority. This also to further reduce the prophylactic use of antibiotics.

Vaccines are approved by the EU, already in action and called upon for further research and application. The EU has projects in this area such as the Action Plan of the European Technology Platform for Global Animal Health and the European Commission's funding for the CSFV-GODIVA project, which demonstrated how public funding can drive the development of safer and more effective vaccines for food producing animals. Therefore, this process is marked light orange, as it is likely that new vaccines for farmed fish will obtain approval.

UNITED STATES

Vaccination is certainly an approved practice in U.S. aquaculture, as it is listed as one of the major commercial markets for aquaculture vaccinations, among those of Northern Europe, Chile and Canada. Furthermore, Schering-Plough Animal Health (a U.S. company) is among the world's major producers of fish vaccines, particularly for Salmon and Trout species.⁵⁸ However, while not specific to the U.S., it should be noted that vaccines (by their traditional definition) are not appropriate for use on Shrimp populations, because they do not possess an adapted or specific immune system. Nevertheless, from a legal perspective, the process was marked as light orange, given that vaccines are generally approved of for aquaculture.

Enzymes as alternatives for antibiotics

EUROPEAN UNION

There is less literature on the use of enzymes as alternatives for antibiotics than on vaccines. However, under Article 27(b) of 2009 Regulation 710/2009, the "Use of certain products and substances in processing of food" are outlined, and among the products and substances that can be used are listed "preparations of micro-organisms and enzymes normally used in food processing".

⁵⁸ Sommerset, I., Krossøy, B., Biering, E., & Frost, P. (2005). Vaccines for fish in aquaculture. *Expert review of vaccines*, 4(1), 89-101.

As such, the process was marked light orange as a process in the same category is approved for food, but the process itself is only possibly on the radar of the regulator.

UNITED STATES

Enzyme preparations can be regulated as secondary direct food additives under Title 21 of the Code of Federal Regulations, Part 173 (21 CFR 173). An enzyme may be either regulated as a secondary direct food additive through a premarket approval process or determined to be GRAS. In either case, the safety determination is limited to the intended conditions of use and the type of enzyme. Both of which need to be specified before a marking can be granted to this ingredient/process. As such, the process was marked light orange as a process in the same category is approved for food.

Anti-quorum sensing bacteria (as the next generation of antibiotics)

There is a lack of data which makes it impossible to assess the legality of this item. Automatic systems to measure water quality/quantity parameters

EUROPEAN UNION

Regulation 710/2009, Art 25f(2) and (3) do call for controls on condition of farmed fish (such as fin damage, other injuries, growth rate, behaviour expressed and overall health) as well as monitoring of the water quality. As such, this process is given a light orange marking as a process in a similar category is approved but the process itself is only possibly on the radar of the targeted market.

UNITED STATES

Very little could be found on the topic from a legislative perspective. However, it is known from studies such as one from the U.S. Southern Regional Aquaculture Centre on “Interpretation of water analysis reports for fish culture”, that the technology is being used in a research setting⁵⁹. Therefore, it could follow from the experiment that the technology can be used in a commercial setting as well. Therefore, this process was given the rating light orange.

Category g) Innovations moving the whole farm production foot print off land

11) Systems (digital or otherwise) that use coproducts including sludge water from pens or ponds

For Shrimp: Biofloc system

No EU or U.S. legal materials found on this topic. Due to a lack of data it is impossible to assess the legality of this item.

Development of algorithms for feeding and behaviour

No EU legal materials found on this topic. Due to a lack of data it is impossible to assess the legality of this item.

Integrated backup farming systems to reduce business risks

No EU or U.S. legal materials found on this topic. Due to a lack of data it is impossible to assess the legality of this item.

⁵⁹ Stone, N. M., Shelton, J. L., Haggard, B. E., & Thomforde, H. K. (2013). *Interpretation of water analysis reports for fish culture*. Southern Regional Aquaculture Center.

Precision feeding

No EU or U.S. legal materials found on this topic. Due to a lack of data it is impossible to assess the legality of this item.

12) Unknown Innovations

1. Floating offshore algae pods

Due to a lack of data it is impossible to assess the legality of this item.

2. Chinampas

No EU legal materials found on this topic. Due to a lack of data it is impossible to assess the legality of this item.

3. Aquaponics

EUROPEAN UNION

Aquaponics falls under the common EU policies related to agriculture, fisheries, food safety and environment. These activities are subject to a significant amount of policies and legislation.⁶⁰

As discussed in a 2018 study by the European Ecocycles Society:

“[Due to the fact that] aquaponics falls into fish as well as plant production relevant policies are the Common Agriculture Policy and the Common Fisheries Policy, the European Union (EU) Food Safety and Nutrition Policy, and the EU Environmental Policy. Goals of these policies that are related to aquaponics include promoting innovation, increasing competitiveness and sustainability, improving access to space and water, welfare of fish, prevention of waste, and promoting resource-efficiency and low-carbon economy.⁶¹ Aquaponics contributes to achieving these goals by minimising water and nutrient use, utilising areas unfit for other food production systems, facilitating local food production and thus providing new business opportunities. The EU provides various frameworks for financial support for the different components of aquaponics, resulting in a range of opportunities for the newcomer as well as the already established aquaponics entrepreneurs. Financial support mostly targets research projects, while the sector also needs assistance in the commercial development.”

As a result of these findings, the process was given the light orange marking, as the process is on the radar of the EU but so far efforts have mainly focused on research projects and little has been done to actually develop the process commercially. However, it is certainly possible to develop Aquaponics further under the current legislative framework.

UNITED STATES

In 2011, the U.S. Environmental Protection Agency (EPA) released the Urban Farm Business Plan Handbook (Handbook) to provide guidance for developing a business plan for the start-up and operation of an urban farm. The Handbook acknowledged aquaponics as a method of producing food in an urban environment. So far, similarly to the EU efforts have mainly focused on research projects and smaller scale operations. Little has been done to actually develop the process commercially. As such, the process was given the green marking as it is on the radar of the U.S. and the process can certainly be developed further under the current legislative framework.

4. Natural ecosystem growing

This is too unspecified to assess the legality and therefore requires further research. In general, it will need to comply with the Marine Strategy Framework Directive, the WHS (work, health and safety

⁶⁰ Hoevenaars, K., Junge, R., Bardocz, T., & Leskovec, M. (2018). EU policies: New opportunities for aquaponics. *Ecocycles*, 4(1), 10-15.

⁶¹ Ibid.

regulations) and other international laws. Depending on where it will take place and which other species it may affect, within EU waters, it may have to comply with the Habitat Directive and national marine protected area legislation.

Annex 2: Tables of the priority options assessed

Table 2.1: FEED INGREDIENTS: Category a): Priority solutions 1a and 1b.

a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO2 and energy. Priority option 1

a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO2 and energy. Priority option 1																	
1a) Protein (processed or concentrated) or starch from locally available food waste stream (15)													1b) Wild Cards				
European Union Salmon	1. Spent grains, distillers dark grain & draff (ales, lagers & spirits)	2. Pomace (apples)	3. Whey, whey concentrate and whey permeate (cheese)	4. Egg shell waste (dried shell)	5. Pomace (skin and seeds) (light wines)	6. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)	7. Fibre, concentrated fruit juice, protein from potato starch, potato protein concentrate	8. Peelings (potatoes)	9. Organic wastes, mash from grain, fruit or potato (spirits)	10. Sugar beet pulp	11. Pomace (skin, pulp & seeds) (tomatões)	12. Crude & extracted press cake or spent meal (vegetable oils/margarines)	13. Olive stones (vegetable oil)	14. Wheatfeed / wheat middlings (wheat milling products)	15. Other innovations	1a) By-products of food industry	1b) Land Animal Protein
	1. Spent grains, distillers dark grain & draff (ales, lagers & spirits)	2. Pomace (apples)	3. Whey, whey concentrate and whey permeate (cheese)	4. Egg shell waste (dried shell)	5. Pomace (skin and seeds) (light wines)	6. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)	7. Fibre, concentrated fruit juice, protein from potato starch, potato protein concentrate	8. Peelings (potatoes)	9. Organic wastes, mash from grain, fruit or potato (spirits)	10. Sugar beet pulp	11. Pomace (skin, pulp & seeds) (tomatões)	12. Crude & extracted press cake or spent meal (vegetable oils/margarines)	13. Olive stones (vegetable oil)	14. Wheatfeed / wheat middlings (wheat milling products)	15. Other innovations	1a) By-products of food industry	1b) Land Animal Protein
United States Salmon	1. Spent grains, distillers dark grain & draff (ales, lagers & spirits)	2. Pomace (apples)	3. Whey, whey concentrate and whey permeate (cheese)	4. Egg shell waste (dried shell)	5. Pomace (skin and seeds) (light wines)	6. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)	7. Fibre, concentrated fruit juice, protein from potato starch, potato protein concentrate	8. Peelings (potatoes)	9. Organic wastes, mash from grain, fruit or potato (spirits)	10. Sugar beet pulp	11. Pomace (skin, pulp & seeds) (tomatões)	12. Crude & extracted press cake or spent meal (vegetable oils/margarines)	13. Olive stones (vegetable oil)	14. Wheatfeed / wheat middlings (wheat milling products)	15. Other innovations	1a) By-products of food industry	1b) Land Animal Protein
	1. Spent grains, distillers dark grain & draff (ales, lagers & spirits)	2. Pomace (apples)	3. Whey, whey concentrate and whey permeate (cheese)	4. Egg shell waste (dried shell)	5. Pomace (skin and seeds) (light wines)	6. Citrus zest, peel, seed, membrane residue after juice extraction (oranges)	7. Fibre, concentrated fruit juice, protein from potato starch, potato protein concentrate	8. Peelings (potatoes)	9. Organic wastes, mash from grain, fruit or potato (spirits)	10. Sugar beet pulp	11. Pomace (skin, pulp & seeds) (tomatões)	12. Crude & extracted press cake or spent meal (vegetable oils/margarines)	13. Olive stones (vegetable oil)	14. Wheatfeed / wheat middlings (wheat milling products)	15. Other innovations	1a) By-products of food industry	1b) Land Animal Protein

Table 2.2: FEED INGREDIENTS: Category a): Priority solutions 2 to 4

a) Nutritional solutions creating net positive environmental effects using waste streams, including but not limited to: food waste, CO2 and energy.												
2			3) Protein from fermentation on processes using waste streams							4		
2) Protein from Insects fed on Food waste and/or food industry coproducts			3a. Microbial - Sustainable CO2 source, Bio-gas		3b. Food waste or food industry co-product (sugars)			3c. Waste product such as: Cellulose	4) Unknown Protein from using energy waste			
Black soldier fly or Common Housefly	House Cricket, Banded Cricket or Field Cricket	Pupae (silkworm pupae meal)	Bacteria (Methanomonas)	Microalgae (Spirulina Arthospira or Chlorella)	Single cell proteins (SCP)	Heterotrophic Algae	Yeast	Fungi	Fungi that grows on cellulose	Sludge	Manure	Use of waste heat for flocculation of proteins from waste streams (eg effluent) Use of waste heat for flocculation of proteins from waste streams (eg effluent)
Black soldier fly or Common Housefly	House Cricket, Banded Cricket or Field Cricket	Pupae (silkworm pupae meal)	Bacteria (Methanomonas)	Microalgae (Spirulina Arthospira or Chlorella)	Single cell proteins (SCP)	Heterotrophic Algae	Yeast	Fungi	Fungi that grows on cellulose	Sludge	Manure	Use of waste heat for flocculation of proteins from waste streams (eg effluent) Use of waste heat for flocculation of proteins from waste streams (eg effluent)
Black soldier fly or Common Housefly	House Cricket, Banded Cricket or Field Cricket	Pupae (silkworm pupae meal)	Bacteria (Methanomonas)	Microalgae (Spirulina Arthospira or Chlorella)	Single cell proteins (SCP)	Heterotrophic Algae	Yeast	Fungi	Fungi that grows on cellulose	Sludge	Manure	Use of waste heat for flocculation of proteins from waste streams (eg effluent) Use of waste heat for flocculation of proteins from waste streams (eg effluent)
Black soldier fly or Common Housefly	House Cricket, Banded Cricket or Field Cricket	Pupae (silkworm pupae meal)	Bacteria (Methanomonas)	Microalgae (Spirulina Arthospira or Chlorella)	Single cell proteins (SCP)	Heterotrophic Algae	Yeast	Fungi	Fungi that grows on cellulose	Sludge	Manure	Use of waste heat for flocculation of proteins from waste streams (eg effluent) Use of waste heat for flocculation of proteins from waste streams (eg effluent)

Table 2.3: FEED INGREDIENTS: Categories b) and c): Priority solutions 5 to 7

	b) Nutritional solutions creating health effects equal to or greater than fatty acids (e.g. DHA-EPA)				c) Nutritional solutions using inputs that create environmentally restorative effects (e.g. ecosystem rehabilitation)		
	5				6		7
	5) Non-marine (non-animal) oil sources of Omega-3				6) Protein from seaweeds (process or concentrated)		7) Protein from insects fed on seaweeds
European Union Salmon	Bacteria	Seaweed	Microalgae	GM terrestrial plants	Seaweed (Red macroalgae)	Seaweed (Brown macroalgae)	Protein from insects fed on seaweeds
European Union Shrimp	Bacteria	Seaweed	Microalgae	GM terrestrial plants	Seaweed (Red macroalgae)	Seaweed (Brown macroalgae)	Protein from insects fed on seaweeds
United States Salmon	Bacteria	Seaweed	Microalgae	GM terrestrial plants	Seaweed (Red macroalgae)	Seaweed (Brown macroalgae)	Protein from insects fed on seaweeds
United States Shrimp	Bacteria	Seaweed	Microalgae	GM terrestrial plants	Seaweed (Red macroalgae)	Seaweed (Brown macroalgae)	Protein from insects fed on seaweeds

Table 2.4: FEED PRODUCTION: Category d): Priority solutions 8 and 9

	d) Technology solutions creating net positive effects using renewable energy, packaging waste, energy waste, sustainable transport.				
	8			9	
	8) Use of solar and wave powder to produce/test feed and ingredients			9) Alternative technology	
European Union Salmon	Pellet extrusion running on solar energy	Extrusion	Packaging free feed	Mapping of local food waste streams to be used in local farms	Extrusion
European Union Shrimp	Pellet extrusion running on solar energy	Extrusion	Packaging free feed	Mapping of local food waste streams to be used in local farms	Extrusion
United States Salmon	Pellet extrusion running on solar energy	Extrusion	Packaging free feed	Mapping of local food waste streams to be used in local farms	Extrusion
United States Shrimp	Pellet extrusion running on solar energy	Extrusion	Packaging free feed	Mapping of local food waste streams to be used in local farms	Extrusion

Table 2.5: FEED PERFORMANCE: Category e), f) and g): Priority solutions 10, 11 and 12

	e) Technology solutions increasing the health, survival and growth performance of the fish/shrimp					f) Integrated information systems solutions increasing feed waste efficiencies				g) Innovations moving the whole farm production foot print off land			
	10					11				12			
	10) Integrated technologies incorporating digital monitoring to increase the health, survival and growth performance of the fish/shrimp (i.e. including digital health control, A.I. biomass control)					11) Systems (digital or otherwise) that use coproducts including sludge water from pens or ponds				12) Unknown Innovations			
European Union Salmon	Biosensor	Vaccines and alternatives for antibiotics	Enzymes as alternatives for antibiotics	Anti-quorum sensing bacteria	Automatic systems to measure water quality/quantity parameters	For Shrimp: Biofloc system	Development of algorithms for feeding and behaviour	Integrated backup farming systems to reduce business risks	Precision feeding	Floating offshore algae pods	Chinampas	Aquaponics	Natural ecosystem growing
European Union Shrimp	Biosensor	Vaccines and alternatives for antibiotics	Enzymes as alternatives for antibiotics	Anti-quorum sensing bacteria	Automatic systems to measure water quality/quantity parameters	For Shrimp: Biofloc system	Development of algorithms for feeding and behaviour	Integrated backup farming systems to reduce business risks	Precision feeding	Floating offshore algae pods	Chinampas	Aquaponics	Natural ecosystem growing
United States Salmon	Biosensor	Vaccines and alternatives for antibiotics	Enzymes as alternatives for antibiotics	Anti-quorum sensing bacteria	Automatic systems to measure water quality/quantity parameters	For Shrimp: Biofloc system	Development of algorithms for feeding and behaviour	Integrated backup farming systems to reduce business risks	Precision feeding	Floating offshore algae pods	Chinampas	Aquaponics	Natural ecosystem growing
United States Shrimp	Biosensor	Vaccines and alternatives for antibiotics	Enzymes as alternatives for antibiotics	Anti-quorum sensing bacteria	Automatic systems to measure water quality/quantity parameters	For Shrimp: Biofloc system	Development of algorithms for feeding and behaviour	Integrated backup farming systems to reduce business risks	Precision feeding	Floating offshore algae pods	Chinampas	Aquaponics	Natural ecosystem growing