Identification of specific demands on Feed in Dutch Organic Aquaculture

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Contents

Summary

The evaluation of specific demands for organic feed focussed on feed demands for four fish species which can be cultured in Recirculation Aquaculture Systems (RAS), tilapia, African Catfish, shrimp and turbot. The evaluation of the various feed formulations indicates that there are several ingredients, which are common for the four species, and will therefore be used for further elaboration on the organic availability. These feed ingredients, are: fishmeal and oil, corn meal, corn meal, wheat meal, blood meal, vitamin mix, mineral mix, and antioxidants.
Besides the evaluation of the feed ingredients an inventory was made on the demands set by three key organic standards and legislation documents; European legislation (in prep), IFOAM and Naturland. A draft consensus standard containing a synthesis of all demands has been described. The implication of the demands, and the possibilities and bottlenecks for organic feed production were evaluated for the selected feed ingredients.
It was concluded that organic feed production for RAS can meet the general criteria set for feed, on GMO material and organic composition. However, for the production of organic feed, a bottleneck will be the necessary requirement of synthetic amino acids for health improvement. The lack of these amino acids in organic feed can result in potential disadvantage for animal needs. This raw material restrictions will most likely also result in the lack of possibilities for fine tuning the feed for animal needs.
The demands set for fishmeal and oil can be met in most of the cases, although the feed ingredient will be more expensive. In order to obtain fishmeal primarily from by catch and trimmings the quality of the fishmeal will be reduced (and waste production increased). In relation to this, there is a growing demand on fishmeal from sustainable sources, which increases competition between organic and conventional feeds. The demands for sustainable fishmeal and oil are not always clear. The exact definition of sustainable sources is not formulated, in some cases the proposed sustainability is not sustainable when considering other topics then fish stocks management (eg. Energy use etc.)
Soybean and wheat meal and gluten are considered as promising ingredients for organic feed,. However, the price settings may be unfavorable due to competition with human nutrition markets.
Animal derived meal may be a viable protein source for organic feed, although the ingredient may not be applicable in organic aquaculture feed. Consumers do not appreciate indirect consumption of terrestrial animals through fish.
Vitamins and minerals may be used in organic feeds when they are from organic sources, or when the alternative is properly justified. Fish require additional amino acids in their diet for health improvement, synthetic amino acids are in some cases allowed as additive, however, the allowance is under discussion. Antioxidants are available as organic ingredient and could therefore be utilized, however further improvement and development is highly needed.

1 Introduction

The feed demand in aquaculture represents approximately 50% of the total production costs, and is an important factor in aquaculture production. The feed ingredients originate from different sources, among these the vegetable fraction and the fishmeal and oil fraction. The use of the latter is under public pressure due to the fact that they originate from wild fisheries, and may have negative environmental impacts. Besides the sources of raw materials the composition and quality of the feed is important for aquaculture systems, because the functionality and effectiveness of the production system (especially recirculation systems) depends, amongst other parameters, on the feed quality.
The industry and authorities are at this moment considering the possibilities of the implementation of organic recirculation aquaculture in the Netherlands. Therefore specific "organic" demands are becoming applicable to the feed. Since the demands for organic and conventional feed production are different, there is a need to obtain information on the potential to produce organic feed. This study describes the main feed components and the bottlenecks associated with organic feed production.

2 Objective

The objective of the project is an inventory of the demands set for organic feed for aquaculture purposes. It aims for generic demands of fish feed, in which no discrimination will be made between feed for tilapia, catfish, shrimp or sole/turbot. A description of the generic components, bottlenecks for organic feed and the availability of these components will be a result of this short study.

3 Methods

The project will primarily aim for generic demands set for feed for fish species, which are produced in the Netherlands in Recirculation Aquaculture Systems (RAS), such as tilapia, Catfish and sole/turbot (and shrimp).
In order to reach the demands set for organic aquaculture feeds a first inventory of used feed (as examples) was made based on literature studies and input from the feed industry. An inventory of possible feed ingredients and their legislative acceptance within the Netherlands was also based on literature studies.

The inventory of the most generic components in feed formulated for Recirculation Aquaculture systems was based on the ingredients, which are general in three aquaculture feeds for different species. This inventory creates the bases for the most commonly used, and required ingredients.
Following the inventory of the ingredients, several available organic standards were evaluated for the demands set for organic aquaculture feed production. The approach was to use the specific demands in the current draft legislation (889/2008/EC) (EC, 2008). After this the demands for the available Naturland standard for aquaculture production, and IFOAM documentation were verified,a and a consensus standard was made. The consensus standard takes into account the European legislation, which is currently in preparation. From these three sources the most stringent demands were combined and set as consensus standard for further application.

The evaluation of the most stringent organic feed demands, and the inventory of the feed components was used for further evaluation, in which the potential and possibility for organic aquaculture feeds were described and summarized.

4 Results

4.1 Inventory of common feed ingredients.

The ingredients of common aquaculture feeds were analysed by means of a quick scan literature study The ingredients were assessed for acceptance according the current feed legislation for aquaculture applications. For a complete overview the protein , crude fat and crude fibre contents of the ingredients are reported (. The feed ingredients, acceptances in the Dutch legislative framework and characteristics of the ingredients are reported (table 1).

Table 1. Characteristics of ingredients Aquaculture Feed

Source	Ingredient	Allowed in NL*	Protein	Crude fat	Crude fibre
			%	%	%
Protein	Fish meal	+	62-72	10	1
Protein	Bone meal	-	17.5	5.2	3.5
Protein	Bone and meat meal	-	> 50	8.5	2.8
Protein	Blood meal	+	80-85	1	1
Protein	Poultry feather meal	-	83	2.5	1.5
Protein	Poultry by product	-	60	14	2.5
Protein	Soybean meal	+	48	1	3
Protein	Canola meal	+	38	3.8	11
Protein	Cotton Seed meal	+	41	2	11
Protein	Peanut meal	+	45-48	5	12
Energy	Maize	+	12.6	16.5	16.3
Energy	Rice bran	+	13.5	12.5	13
Energy	Wheat bran	+	15	1.9	3
Energy	Wheat middlings	+	17.7	3.6	7
Energy	Wheat gluten	+	80	6-8	10
Energy	Corn grain	+	8.9	3.5	2.9
Energy	Fat	+	0	99	0
Vitams	Vitamin mix	+	Na	Na	na
Minerals	Mineral mix	+	Na	na	Na
Antioxidants	Etoxyquine	+	na	na	Na

Ref: http://www.thefishsite.com/articles/171/catfish-nutrition-feeds
(Dale 1998), (Lim 2007), (Helland and Grisdale-Helland 2006)

4.2 Inventory of formulated Feed

This section describes the characterisation of common ingredients in specified feeds for tilapia, Catfish (RAS), Turbot (Flow through) and Shrimp (Pond). The required information was derived from industrial labels or literature sources. In many cases exact compositions could not be obtained, therefore the indicated figures are indicative for the represented species. The inventory of used feed formulations is shown in table 2.

The results show several ingredients common for the four species. These ingredients will be used for further elaboration on the organic availability. These are: fishmeal and oil, corn meal, corn meal, wheat meal, blood meal, vitamin mix, mineral mix, and antioxidants.

Table 2. Examples of Feed formulation Aquaculture species (turbot, tilapia, catfish, shrimp) for RAS Total does not meet 100%, since exact formulations are not specified in detail. ****

Ingredient	**Tilapia**** **(% of feed)**	**A. Catfish* (% of feed)**	**Turbot*** **(% of feed)**	**Shrimp** (% of feed)**
Fish meal	13	50	45	23
Hydrolysed protein	-	-	5	-
Blood Meal	-	-	5	-
Yeast	-	-	-	3
Wheat meal	>20	23	6	29
Wheat gluten			14	
Rice Bran	-		-	-
Corn meal	>20	-	-	-
Soy bean meal	>34	9	5	15
Pea meal			5	
Fish oil	6	5-7	9	1
Vegetable oil		<5		
Poultry oil		<5		
Calcium Diacid phosphate	-	-	2	2
Dicalcium phosphate	-	-	-	2.5
Phosphatid	-	-	1	-
Choline	-	-	0.5	-
Vitamin mix	0.5	+1	0.5	-
Mineral Mix	0.5	+1	0.5	-
Antioxidants	Present	Present	Present	Present
Not specified	<6	<7	2.5	25

* African catfish (*Skretting, labelling 2008)*
** Hasan, 2007
*** Turbot meal as formulated by Skretting for recirculation systems (Skretting labelling 2008)

4.3 Inventory Organic Feed demands

The organic feed requirements are presented in table 3. The standards and the demands set by the standards all have a lot in common. The reason for this, is that they share the same philosophy, and input for the set up of the documents is based on the same arguments, and sometimes with input from the same equip of people. Also the demands are quite similar because the demands suffer from the same shortcomings in global organic/sustainable raw material availability, and the quality of the raw material. One example is that not all fishmeal requirements can be replaced by product based on trimmings due to the poorer quality of the fishmeal derived. Therefore the fishmeal production method needs to be improved, or fishmeal has to originate from sustainable controlled fisheries.

Table 3. Summary of feed requirements in general organic feed standards, based on draft European legislation (EC, 2008), Naturland standards, and IFOAM-Basic standards. The different standards and legislation were combined into a consensus standard, in which the strictest demands are taken into account for further processing.

Issue	Specification	EU	IFOAM	Naturland	Consensus standard
Feed composition	Formulated for animal health	X	X	X	X
Feed composition	Formulated for high product quality	X	n.s.	n.s.	X
Feed composition	Formulated for low environmental impact *	X	n.s.	n.s.	X
Feed composition	Formulated for specific need of animal	X	X	X	X
Raw material	No GMO material	X	X	X	X
Raw material	No synthetic Amino acids	n.s.	X	n.s.	X
Raw material (excl. Fishmeal and oil)	Organic source	X	<15% non organic	IFOAM or Naturland certified	IFOAM or Naturland certified
Raw material	Inclusion terrestrial animals	n.s.	Not allowed	X	Not allowed
Fishmeal and oil	preference for trimmings of fish already caught for human consumption in sustainable fisheries	X	X (>50% of fishmeal)	X	X (>50% of fishmeal)
Fishmeal and oil	fishmeal and oil from sustainable exploitation of fisheries	X	X	X	X
Fishmeal and oil	trimmings of fish caught for human consumption may be used	for a transitional period until 31 December 2014	Exceptional	<30% if needed	Exceptional
Fishmeal and oil	By-catch of fisheries for human consumption may be used	n.s.	X	X	X
Fishmeal and oil	From same geographic region as operator	n.s.	X	n.s.	X
Fishmeal and oil	Not exceed X% of the daily ration for omnivorous species.	30%	50%	n.s.	50%
Fishmeal and oil	The use of fish hydrolysates and proteolysates shall not be limited to young aquaculture animals.	X	n.s.	n.s.	X
Fishmeal and oil	The ration of non-herbivorous species should comprise at least 10% plant proteins from organic production.	X	n.s.	n.s.	X
Fishmeal and oil	Complete substitution of fishmeal and fish-oil in carnivorous species is not advised on welfare grounds.	X	n.s.	n.s.	X
Antioxidants	Only natural	X	X	X	X
Feed additives	Vitamins and minerals	Permitted feed additives are listed in Annex VI of Regulation 889/2008.	Permitted where essential	n.s.	Permitted feed additives are listed in Annex VI of Regulation 889/2008.
Production of soy meal	Solvent extraction	n.s.	Not permitted	n.s.	Not permitted

1) Ref. Working Document_Rev. 2 – Organic Aquaculture and Seaweed, Commission Regulation, Amending Commission Regulation 889/2008[1] on detailed rules for organic production labeling and control with regard to organic aquaculture and *seaweed (Article 17).,* 2) Ref. IFOAM, 2006, 3) Ref. Naturland, 2008,
* Mainly in relation to the production system and water purification
n.s. = not specified.

4.4 Availability feed ingredients and comparison with organic standards

4.4.1 General Feed demands

Based on the comparison of existing standards, and the compilation of a consensus standard, the results of the general feed demands are selected in table 4. In order to evaluate the agreement of the conventional feed with organic standards an inventory is made on the different topics set in the (consensus) standard. This is followed by an evaluation of the possibility for the feed production to fulfill the organic demands.

Table 4. General feed demands, based on a consensus organic standard.

Issue	**Specification**	**Consensus standard**	**Conventional Feed**	**Possibility Organic**
Feed composition	Formulated for animal health	X	+	+
Feed composition	Formulated for high product quality	X	+	+
Feed composition	Formulated for low environmental impact	X	+/-	+
Feed composition	Formulated for specific need of animal	X	+/-	+/-*
Raw material	No GMO material	X	+/-	+
Raw material	No synthetic Amino acids	X	-	+
Raw vegetative material (excl. Fishmeal and oil)	Organic source	IFOAM or Naturland	-	+

X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible
* Pelleted feed require specific demands on formulation for binding of the pellet. Special formulations for organic pelleted feed needs further development.

For feed composition the organic regulation demands that feed are formulated to suit the demands set for animal health. The conventional feed industry has the same ambition concerning animal health issues, and therefore strives to optimize the feed to the known demands of the fish. However, in many cases the feed are primarily formulated to fulfill generic demands on proteins, fat and fibers, without specific attention to the exact requirements for specific species. Table 1 givesthe generic nutrient requirements of the target fish species. The feed industry has the potential to further fine tune feed composition in an organic applicable way. The costs for this can only be justified by an certain production volume. With this respect (increasing) knowledge on animal health and nutrition should be used in the feed composition methodology, especially for organic feeds.

High quality products need to be available for organic aquaculture, as well as for high quality products for conventional feeds. However, the product quality depends on the available raw material, and the price setting of the material. To achieve high quality products there is a continuous need for an adequate and stable supply of high quality raw materials. In order to achieve this for organic feed, the market (and price setting) for organic feed as well as, the supply of raw materials should be organized in such a way that commercial production of high quality feeds is viable. However, the market of organic products is still growing at this moment, and supplies of vegetative raw materials at this moment also provide the human consumption chain. Therefore there is increasing competition on high quality products between the feed and food industry. A growing organic raw material market should result in improved selection of high quality raw material for the feed industry.

The formulation of the feed according to the specific needs of the animal is one of the bottlenecks in organic aquaculture. For many species the specific needs for the fish are known for nutrient requirements, and vitamin balances, also the natural feed of many fishes is known. However, for aquaculture purposes there is discussion on what the demands in organic feeds should be. For carnivorous species this would mean that the diet should be composed of only fish, since this is their natural requirement. However, Bridson (2008) reported that there is a need of approximately 10% of vegetable ingredients, for the binding of the feed pellets (starch source). Feed pellet properties are of utmost importance in recirculation systems as both feed remains and faeces have to be removed from the water. Hence, characteristics such as palatability, water stability and digestibility are highly important for feeds used in recirculation systems.
Next to that the impact of an increase of fishmeal has an increasing negative influence on the ecological footprint, which is not desirable in many cases. Therefore a balance should be found in the natural feed demand of the cultivated fish, and the production potential of the feed. In general the feeds should be of high quality and should suit the animal health demands. The formulation of the specific natural animal needs are not always practically implementable.

For current conventional feed production in some cases GMO material is used. In organic feed sources GMOs should be absent, and therefore the supplied raw material will also be obliged to be GMO free. Fortunately, non-GMO material is widely available, and certification of these materials is also available. There are however discussions on the sensitivity of detection and verification of GMO-free materials, which will not be discussed in this document.

In current feed production synthetic amino acids are used in the diets. The reason to do so is to provide the best suitable balance of amino acids in the fish diet. Fish, like terrestrial animals, do not have specific protein demands, but they have a requirement for amino acids (amino acids are the building stones of proteins). When providing efficient proteins in the feed the feeding rates decrease, and therefore less feed per unit of fish (Feed Conversion rates) is needed. This will also result in a decrease in waste production since the proteins are metabolized very efficient. However, in organic production schemes, the addition of synthetic amino acids is not allowed. Aquaculture feed can be very well produced without the use of synthetic amino acids. However, to obtain efficient use of organic fish feeds this will require the use of ingredients with the best possible amino acid profiles. Fishmeal is as such the product with the best protein quality. In general second best amino acid profiles have (by-)products from terrestrial animals, such as meat and blood meal. The plant ingredient with a good amino acid profile is soya. However, many fish species (e.g. salmon) have difficulties in digesting soya and may develop ulcers in the digestive tract if considerable amount of soya are used in the feed.

4.4.2 Fishmeal and oil

Table 5 shows the demands set for the fishmeal and oil supplies for organic feed production. Strict organic standards demand that at least 50% of the production of fishmeal and oil should be derived from trimmings of fish, which are caught by sustainable fisheries. Gafta reports that around 30% of the fishmeal and oil production is derived from trimmings (FIN, 2006). Industrial sources report the use of around 20% of trimmings in North European fishmeal production. In the UK it was reported that around 50% of the total fishmeal production could be derived from trimmings. The use of trimmings do not necessarily imply trimmings from sustainable fisheries, but also cover trimmings and by-catch from non-certified (not necessarily not sustainable) fisheries.
The use of trimmings for production of fishmeal does imply difficulties for product quality. Since the trimmings mainly consist of fish bones and bone-connected tissue, the protein levels are less and the quality of the proteins is lower than those of dedicated fishmeal production. Therefore the use of more than 50% of fishmeal derived from trimmings can not meet optimal product quality at this moment (Skretting, pers. Comm. 2007). Life Cycle Analyses studies performed by Tyedmers indicate that the replacement of conventional fishmeal by fishmeal derived from fisheries by-product indicate has a larger impact than the reduction of fish meal in the feed. Also the environmental impacts were considered to be lower when a reduction of animal derived ingredients is performed (Pelletier and Tyedmers 2007; Pelletier, Ayer et al. 2007).
The availability of trimmings derived from sustainable fisheries does not yet meet sufficient quantities to supply the total demand for the sustainable aquaculture development, and therefore will hamper the supply for organic feeds as such. An increase of certified sustainable fisheries will result in an increase in trimmings, and thus provide more market supply for the organic feed production. This development should co-occur with the traceability systems on the trimmings, for control purposes as well as to avoid intra-species feeding (to avoid the potential risks of disease spread).

The market availability for certified sustainable fisheries for fishmeal production is at this moment scarce. Also the demands which need to be set for organic certification are not always clear. Fishmeal can be obtained from sources, which are caught under the principles of FAO Code of Conduct for Responsible Fisheries 1995, the European Code of Sustainable and Responsible Fisheries Practices, MSC sustainable certification (generally recognized in organic aquaculture). For industrial fisheries to be sustainable they shall be subject to an effective management system that respects local, national and international laws and standards and incorporate institutional and operational frameworks that require fishing of the resource to be responsible and within limits set by scientific advice. The Commission plans to come forward with a proposal for stimulation of the preparation of a European standard for sustainable fisheries which shall be the future basis of determining sustainability of sources of fishmeal and fish oil for organic feed.
The certification for sustainable fisheries is growing, but does not meet the growing total demands, which are a result of increasing growth of sustainable aquaculture production through out the world. Also the certified fisheries cannot continuously supply the same quality and quantity of fishmeal through out the year, due to inter-annual and annual variations, and seasonal variations in protein content. The changes in quality result in the fact that feed producers mix fishmeal from different origins to ensure that seasonal variations (and price variations) are compensated throughout the year. These situations have the consequence that multiple certified fisheries regimes (globally) should be put into place. Momentarily the certification of various fisheries for fishmeal production are under development. In order to overcome these problems, small-scale production of fishmeal dedicated to organic markets may be promising .
The use of by-catch of sustainable fisheries in some standards is one of the demands of the organic standards. The demand for production of fishmeal in the same geographical region as the production of the fish may be viable for the North European aquaculture. This does imply that specific fishmeal production in every Northern European country should be realized, which will most likely result in less efficient production possibilities with possible increased environmental effects. However, if the organic market for fishmeal (and feed) is great enough, this will offer more possibilities (Dias, 2008).

Issues regarding the fishmeal (minimal and maximum) content of the feed, as well as vegetative fractions are already incorporated in the feed formulation of recirculation aquaculture feeds, and therefore do meet the criteria set for organic production.

Table 5. Demands for fishmeal and oil, based on a consensus organic standard

Issue	**Specification**	**Consensus standard**	**Conventional Feed**	**Organic Feed**
Fishmeal and oil	preference for trimmings of fish already caught for human consumption in sustainable fisheries	X (>50% of fishmeal)	-	+/-
Fishmeal and oil	fishmeal and oil from sustainable exploitation of fisheries	X	+/-	+
Fishmeal and oil	trimmings of fish caught for human consumption may be used	Exceptional	+	+
Fishmeal and oil	By-catch of fisheries for human consumption may be used	X	-	-
Fishmeal and oil	From same geographic region as operator	X	-	-
Fishmeal and oil	Not exceed X% of the daily ration for omnivorous species.	50%	+	+
Fishmeal and oil	The ration of non-herbivorous species should comprise at least 10% plant proteins from organic production.	X	+	+
Fishmeal and oil	Complete substitution of fishmeal and fish-oil in carnivorous species is not advised on welfare grounds.	X	+	+

X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible

4.4.3 Soybean and wheat meal

Soybean meal is one of the most widely used alternative protein sources and studies of soybean meal as a replacement for fishmeal have been performed on various fish species. Soybean meal has a global distribution, proper cost ratios, relatively high digestibility, good amino acid profile and high protein content (Storebakken, 2000). Soybean and other vegetable protein meals contain anti-nutritional factors that negatively impact production performance of cultured aquaculture species (Francis, 2001).
LCA-analyses of various aquaculture feeds indicated that the replacement of animal derived meals (such as fishmeal) by plant proteins, resulted in a positive effect on the impact of the production. This effect becomes greater when the plant protein fraction in the feed is increased (Pelletier and Tyedmers 2007).

There is a requirement of the incorporation of organic soy and wheat meal in the feed as a potential protein provider. Due to the poor (but increasing) availability in the current market and the competition with human consumption markets the price of organic soy is high. Beside the market effect on the price, soy and wheat must also be grown and processed organically which is labor intensive, and crop yields are slightly lower then conventional grown crop (Badgley, 2007). The production of meal from wheat and soy beans is more labor intensive since the oil must be mechanically removed without the aid of the solvents used at most commercial soybean plants (Manitoba, 2008), and therefore prices are higher. Badgley calculated that organic crop production could contribute substantially to the world demand of crops, which indicates that the availability of organic wheat and soy beans may be possible for organic feed purposes in the future (Badgley, 2007). At this moment the supply of organic crops for feed purposes is dependent on the price setting. Skretting reported 15-35% inclusion of vegetable meals could be realized in salmon and trout diets, which should therefore be possible for African Catfish as well (based on table 3). Pelletier reported that substitution of conventional crop by organic crop, in current feed formulations, resulted in improvement of the environmental performance of feed production. Ingredients. The use of organic soy meal, which averages 75% of the life cycle impacts of conventional soy meal, would result in great improvements (Pelletier, 2007). However, the improvements a total organic feed are expected to be neglectable, when also considering the animal-derived ingredients.

Vegetable oils are seen as potential replacements for fish oil in aquaculture feeds. The price setting is at this moment not suitable for the feed industry due to the high competition with the human consumption market. Also vegetable oils (e.g. canola and soy) lack a proper content of polyunsaturated omega fatty acids, which are desirable for the health of both the cultured organism and consumers of fish products (Glencross, 2003). Although research has also indicated that substitution of a large portions of fish oil result in no significant effects in salmon, and sea bass culture (Richard, 2006). These results indicate that there is a need for species-specific research on the possibility of fish oil replacement. However, since the price setting for organic vegetable oil is high replacement of fish oil for organic feeds is not desirable. Besides the price, there is also discussion about the naturalness of replacements for omnivorous and carnivorous species.

Table 6. Demands for raw vegetable material, based on a consensus standard

Issue	**Specification**	**Consensus Standard**	**Conventional Feed**	**Organic Feed**
Raw vegetable material (excl. Fishmeal and oil)	Organic source	Organic Source	-	+

X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible

4.4.4 Animal origin meal

Fishmeal is considered to be the most functional and efficient dietary protein source for carnivorous/omnivorous fishes. Considering alternative protein sources, they must not negatively affect the performance of the fish and pricing should be competitive. Alternative proteins should be available from organic production systems and suitable for pelleting. There are some suitable animal protein sources for the aquaculture industry, such as blood meal, hydrolyzed feather meal, and bone meal. However, these components are not allowed according to some organic standards or even by some national regulations (see table 3 and 6). Bone meal and hydrolyzed feather meal is not allowed in the Netherlands. Bone meal is not allowed within Europe. Poultry oil is allowed in the Netherlands, but is not allowed in eg. Germany. Therefore there is a discrepancy in the European Legislation, which way hinder sustainable developments. Animal proteins are available from organic sources, and could be processed to functional use for aquaculture purposes. These animal proteins suit the dietary demands of the aquaculture species, and could therefore provide an interesting basis for the substitution of fish meal proteins. The major concern of using terrestrial animal material lies in the transmission of diseases, on which special attention (and research) is needed. Besides the legislative framework many organic consumers have fundamental resistance to consuming terrestrial animals through fish, these consumers generally exclude terrestrial animal sources from their personal diets.

Different LCAs of animal products have indicated that the animal originating feed components (both fish and terrestrial animals) contribute negative to environmental impacts to a large extent (Pelletier, 2008). This is a result of the high production efforts, and inputs for animal production, which is also seen in the fishmeal production from by catch. However, as long as complete vegetable based diets are not an option for carnivorous/omnivorous species, there remains a need for animal derived proteins. The use of rest products from the animal production could contribute to a reduction of the environmental impact, since the material does not need to be destructed, fishing effort can be reduced and rest material is re-used. Bone meal, and blood meal could be made organically available, since the source organisms (terrestrial animals) are all bred and produced according to organic standards). For organic (and even conventional) purposes there should be legislative possibilities.

Table 7. Demands for animal origin meal, based on a consensus organic standard

Issue	**Specification**	**Consensus standard**	**Conventional Feed**	**Organic Feed**
Raw material	Inclusion terrestrial animals	Not allowed or n.s.	-*	+

n.s. = not specified.
X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible
* In conventional feed different member states within Europe apply different rules for application of bone meal, poultry oil and hydrolised feather meal. A minus score is presented since in all feed applications an animal source is included.

4.4.5 Mineral and Vitamin Pre-Mix

Premixes are added to fish feeds for the purpose of sound growth of the animal. Premixes consist normally of a "filler" (e.g. wheat meal). The filler makes up the largest part of the pre-mix, but the most important part of it is a mixture of minerals and vitamins that is added. These vitamins and mineral mixture are formulated according to the specific needs of the fish species. Premixes generally contribute only 0.5 to 5% to the weight of the feed.
Present practice in fish farming is that premixes for organic feeds are identical to those used in conventional feeds. This means that also synthetic vitamins are allowed in premixes of organic fish feeds. Justification of this can (partly) be found in the above all intended care for the welfare of the fish. The fish require proper vitamin quantity and quality in their feed in order to comply with the health needs. It is also not unusual that ingredients used in very minor quantities, are difficult to obtain from organic sources. Therefore they are allowed (by the certifier) to be included in organic feeds if properly justified. However,there are fundamental discussions on the organic nature of this acceptance. For the possibility of application of vitamins and minerals in organic aquaculture feeds, this would mean that if acceptance about the lack of proper alternatives is generated, this demand can be fulfilled (see table 8).

Table 8. Demands for vitamins and minerals based on a consensus organic standard.

			Conventional feed	Organic Feed
Feed additives	Vitamins and minerals	Permitted feed additives are listed in Annex VI of Regulation 889/2008.	-	+

X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible

4.4.6 Antioxidants

Due to the high-unsaturated nature of fatty acids in fish oils the spoilage (by oxidation) during storage and transport is high. Therefore the antioxidants are needed for efficient production of fish feed. The main antioxidants used in fishfeed are: Butylated hydroxytoluene (BHT), Butylated Hydroxyanisole (BHA), and ethoxyquin. Organic aquaculture feed do however not permit the presence of synthetic antioxidants in the feed (table 9). Several studies on the replacement candidates of these antioxidants have been performed, and alternatives for the anti oxidants have been found. Naturland proposed functional natural antioxidants, such as gallate, tocopherol for feed production. Kemin has launched Paradigmox Green as a replacement of ethoxyquin that can be used as an antioxidant in fish feeds certified for use in organic aquaculture (accredited by the Soil Association). Also is rosemary oil is seen as a suitable alternative antioxidant in case of European Sea bass (Palmegiano, 2008). The development and optimization of cost-effective natural antioxidants from for example botanical sources is however highly needed.

Table 9. Demands for antioxidants based on a consensus organic standard

Issue	**Specification**	**Consensus standard**	**Conventional Feed**	**Organic Feed**
Antioxidants	Only natural	X	-	+/-

X = Demand of the standard
+ = In accordance to the demand
- = Not in accordance of the demand or not realizable on short-term
+/- = In some cases in accordance to the demands or possible

5 Conclusions

We conclude that organic feed production for RAS can meet the general criteria set for feed, on GMO material and organic composition. However, for the production of organic feed, a bottleneck will be the necessary requirement of synthetic amino acids for health improvement. The lack of these amino acids in organic feed can result in potential disadvantage for animal needs. This raw material restrictions will most likely also result in the lack of possibilities for fine tuning the feed for animal needs.
The demands set for fishmeal and oil will be realizable in most of the cases, although the feed ingredient will be more expensive. In order to obtain fishmeal primarily from by catch and trimmings the quality of the fishmeal will be reduced (and nutrient outputs increased). In relation to this there is a growing demand on fishmeal from sustainable sources, so that there is greater competition between organic and conventional feeds. The demands for sustainable fishmeal and oil are not always clear, the exact definition of sustainable sources is not formulated, in some cases the proposed sustainability is not sustainable when considering other topics then fish stocks (eg. Energy use etc.)
Soybean and wheat meal and gluten are considered as promising ingredients for organic feed, however the price settings may be unfavorable due to competition with human nutrition markets.
Animal derived meal may be a viable protein source for organic feed, however the ingredient may not be applicable in organic aquaculture feed. Many consumers do not appreciate indirect consumption of terrestrial animals through fish.
Vitamins ad minerals may be used in organic feeds if they are from organic sources, or the alternative is properly justified. Fish require additional amino acids in there diet for health improvement, synthetic amino acids are in some cases allowed as additive, however the allowance is under discussion. Antioxidants are available as organic ingredient and could therefore be utilized, however further improvement and development is highly needed.

6 Quality Assurance

IMARES utilises an ISO 9001:2000 certified quality management system (certificate number: 08602-2004-AQ-ROT-RvA). This certificate is valid until 15 December 2009. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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The scientific quality of this report has been peer reviewed the head of the department of Wageningen IMARES.

Approved: Ir. H. van der Mheen
Head of Department Aquaculture

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