On farm seasonal feed utilisation and proximate composition of post-smolt Atlantic salmon (Salmo salar)

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Environmental conditions strongly influence fish physiology causing alterations in metabolic needs accordingly, particularly when seasonal fluctuations are encountered. Temperatures above 18°C are considered extreme for Atlantic salmon, generally resulting in depressed feeding, slowed growth and depletion of body energy stores. Atlantic salmon farming in Tasmania, Australia, competes with challenging seasonal temperatures above 20°C, and with continued warming of the globe such temperatures are likely to become more common in traditionally cooler salmon farming regions such as Scotland and Norway. Determining how Atlantic salmon metabolism and body energy stores change leading into, during, and post long term real-world exposure to these high temperatures is important for the development of husbandry practices. Atlantic salmon were sampled at three commercial sites in Tasmania at bi-monthly intervals with simultaneous monitoring of their feeding and growth performance, and the environmental conditions in their grow-out environment. Fillet and whole body proximate compositions were well aligned through the grow-out period. Lipid content was higher in salmon at cooler sites and fluctuated between visceral stores and fillet stores during periods of faster growth. Changes in feed utilisation were observed across both macro and micro-nutrients when comparing fish through each season, and with changing fish size. Within sites, the estimated lipid deposition efficiency ranged by a factor of 30% dependant on season. MUFA and PUFA were observed to be deposited evenly through spring, with SFA apparently being burned for energy. During summer, SFA was seemingly deposited more efficiently than MUFA or PUFA, and a clear sparing effect was apparent for n-3 LC PUFA. Each sites unique environmental conditions, and resulting proximate composition and feed utilisation, highlight the potential benefits of site and season specific tailored diets, particularly with respect to lipid composition. Ideally, individual farms and their feed suppliers require a detailed understanding of their grow-out environments, where discrete conditions ultimately dictate the site productivity and influence final product composition. These important metabolic and physiological changes observed during warmer Tasmanian conditions have direct application to the global Atlantic salmon industry as sea surface temperatures continue to rise and challenge industry productivity.

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Growth performance, fatty acid profile and meat quality of large Nile tilapia "Oreochromis niloticus" fed diets supplemented with linseed oil and raised under suboptimal temperature

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Four fishmeal-free diets were formulated to be isonitrogenous (321.2 g kg-1), isocaloric (17.1 Mcal kg-1) and isolipidic (73.1 g kg-1), containing two sources of vegetable oils (soybean oil or linseed oil) supplemented at two levels (15 or 30 g kg-1). A hundred and forty-four fish (1.1 ± 0.04 kg) were distributed in a completely randomized 2x2 factorial scheme, into twelve 1000 L floating cages. Fish were hand fed and reared at 18 to 24 oC, during 6 wk. Higher weight gain, feed intake and improved feed conversion ratio were observed in fish fed 30 g kg-1 of linseed oil compared to fish fed 15 and 30 g kg-1 of soybean oil ($p < 0.05$). Fillet yield of fish fed 30 g kg-1 of linseed oil was higher compared to observed in fish fed 30 g kg-1 of soybean oil ($p = 0.006$). No differences in initial body weight, hepatosomatic index and proximate composition of fillets were observed ($p < 0.05$). Fish fed 30 g kg-1 of linseed oil showed higher 18:3n-3 ($p = 0.012$) and lower 18:2n-6 ($p = 0.021$) content in the fillets compared to fish fed 15 and 30 g kg-1 of soybean oil. Fish fed 30 g kg-1 of linseed oil showed higher content of polyunsaturated fatty acids ($p = 0.002$) and n-3 fatty acids ($p < 0.002$) in the fillets. Fillet of fish fed linseed oil showed lower n-6/n-3 ratio compared to fish fed soybean oil ($p < 0.001$). Color, water holding capacity, pH and hardness of fillets were not affected by treatments ($p > 0.05$). In conclusion, linseed oil was demonstrated to be emerging functional food as α-linolenic source to enhance n-6/n-3 ratio of the fillets. Linseed oil supplemented at 30 g kg-1 in diets is recommended to improve growth performance of large Nile tilapia reared under suboptimal temperature.

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Reducing long chain omega 3 polyunsaturated fatty acids in formulated diets for harvest size Yellowtail Kingfish (Seriola lalandi) – is there a trade-off between levels of omega-3 and omega-9 in some tissues?

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There have been no published studies on optimal dietary fish oil levels for harvest sized (>2kg) Yellowtail Kingfish. Altering dietary fish oil is likely to affect the fatty acid composition of the flesh, especially the content of long-chain omega-3 polyunsaturated fatty acid (LC n-3 PUFA; ∑eicosapentaenoic acid [20:5n-3, EPA], docosapentaenoic acid [22:5n-3, DPA] and docosahexaenoic acid [22:6n-3, DHA]), which is important to consumers. Yellowtail Kingfish (average final weight 3.79kg) were fed one of eight experimental diets that ranged in LC n-3 PUFA from 0.753 to 2.950g /100g feed by blending different amounts of fish oil with poultry oil. After 12 weeks, white and red muscle samples were collected for fatty acid analysis. Whilst increased dietary fish oil resulted in increased levels of LC n-3 PUFA in the flesh, there was an indication that white muscle LC n-3 PUFA was conserved at the expense of omega-9 fatty acids when the fish were fed lower levels of fish oil (below 1.821g LC n-3 PUFA /100g feed). Interestingly, red muscle LC n-3 PUFA was not conserved in the same way. No previously published studies have shown this trade-off between omega-3 and omega-9 in the tissues of an aquaculture species. Further research is required to investigate how manipulating the proportion of omega-9 fatty acids in the diet could be useful in managing the sustainable use of fish oil in diets for Yellowtail Kingfish and other farmed fish.

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Nutritional evaluation of seafood available to consumers in the UK

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The consumption of seafood as part of a balanced nutritious diet is supported by health advisory bodies worldwide. Seafood is a rich source of protein, minerals and other micronutrients, but is also the primary dietary source for humans of the beneficial omega-3 (n-3) long-chain polyunsaturated fatty acids (LC-PUFA), eicosapentaenoic (EPA, 22:5n-3) and docosahexaenoic (DHA, 22:6n-3). Although there is no global consensus on EPA+DHA intake, with intakes varying between 250-1000 mg per day, the Global Organization for EPA+DHA omega-3's (GOED) recommends a daily intake of 0.5 g EPA+DHA, equivalent to 3.5 g per week, for optimal cardiac health in adults. To ascertain the contribution of seafood to the dietary intake of key nutrients including. In particular, EPA+DHA, a study was undertaken to examine the nutritional profile of various seafood products (fish, shellfish and cephalopods), of both wild and farmed origin, available to consumers in the UK. In total, over 90 different seafood products purchased during 2016-2017 from a variety of retailers (supermarkets, fishmongers and online) were analysed. The study found that protein content ranged from 8% in seafood sticks to around 27% in albacore tuna. Energy content was related to lipid content, with higher energy values in fattier species (e.g. mackerel, farmed salmon). In terms of fatty acids, farmed species tended to have higher levels of the terrestrial fatty acids, oleic (18:1n-9), linoleic (18:2n-6) and α-linoleic (18:3n-3) than wild species due to the increased inclusion of vegetable oils in their diets, although EPA+DHA contents remained equal to or greater than their wild equivalents. Overall, EPA+DHA levels in seafood ranged significantly, reflecting the variation in lipid contents from 2.6 g to 0.001 g EPA+DHA per 100 g in mackerel and pangasius, respectively. Consequently, this equates to consuming just one 130 g portion of mackerel to meet the 3.5 g EPA+DHA weekly intake, two portions for farmed salmon and trout through to a total of 220 portions for pangasius. These results demonstrate the wide variation in EPA+DHA levels and other nutrients and the potential need to re-evaluate current dietary seafood intake guidelines to consumers.

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Whole body proximate, amino acid, fatty acid and elemental composition of Atlantic salmon (Salmo salar L.) at harvest size from commercial farming in Norway 2017.

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There are few data available on whole fish composition of average harvest sized from the salmon industry. Both feed composition, the genetic material of fish and management of production are changing (Ytrestøyl et al., 2015, Gjedrem, 2000). Data from field experiments also indicate that difference in chemical composition may exist depending on location, time of year and feed content. Feed resources needed for culturing salmon is primarily determined by the composition of the fish and the losses the fish has related to digestion and metabolism. Many of an animal's nutrient requirements can be calculated if the composition of body mass added through growth, the maintenance requirement, and utilization of the specific dietary nutrient is known.

To be able to create an updated resource utilisation budget for Norwegian salmon industry, new data on chemical composition of fish was collected. Salmon of average harvest size, given commercial feeds was sampled from commercial farms at three locations, south, middle and north of Norway at three different times of the year, end of April, August and November.

At each sampling 10 fish of 5.3±0.3 kg were sampled from processing line, after electroshocking but before bleeding, and killed by stunning and transported fresh to Sunndalsøra for analysis. There the fish was frozen at -20 oC, cut in slices by meat saw, pooled and ground two times by a 7.5 hp meat grinder, mixed and a sample of 100 g taken for freeze-drying for further analysis according to standard procedures. Whole fish was analyzed for proximates, amino acids, fatty acids and some selected elements.

Preliminary results show an average content of (g/100 g): protein, 17; lipid, 22; ash, 1.8; lysine, 1.37; methionine, 0.50 and (mg/kg) phosphorus, 3180; calcium, 3550; zinc, 33. Compared to harvest sized whole fish data presented by Shearer et al. (1994) the lipid level is slightly higher and ash content slightly lower but similar to values given by Ytrestøyl et al., (2015). The values for all measured parameters will be presented.

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Growth performance and nutrient utilisation of Senegalese sole fed vegetable oils in plant protein-rich diets from juvenile to market size

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Senegalese sole (Solea senegalensis) is a prized flatfish produced in Europe with demonstrated capacity to cope well with both vegetable protein and oil sources. But the concomitant inclusion of vegetable oils (VO) and plant protein (PP) has been poorly evaluated in this species. Three extruded isoenergetic (23 KJ/g) and isolipidic (15 % DM) practical plant protein-based diets (75% PP) were formulated: a control with fish oil, FO (CTR) and two experimental diets with increasing levels of a blend of vegetable oils (50% VO50 and 100% VO100). All diets contained a blend of protein sources and were supplemented with L-Lys, L-Tryp, and DL-Met to satisfy the essential amino acid requirements. Triplicate groups of fish (13.3±0.9g) were kept in a recirculation saltwater system at 19 oC and fed the experimental diets ad libitum during 18 months. Fish were sampled after 6 and 18 months to monitor weight gain and feed consumption. The total substitution of FO by VO (VO100) during the juvenile phase (6 months of feeding) significantly reduced final body weight, daily growth index, and protein gain, and increased FCR. A longer feeding period (after 18 months) showed that VO inclusion had no major effects on fish growth, but FCR was significantly higher in fish fed VO100 than in CTR. At the end of the trial, muscle saturated FA level decreased with increasing dietary VO, whereas monounsaturated and poly-unsaturated FA level increased in fish fed VO diets. Despite the lower values of DHA and EPA in the muscle with VO inclusion, the linoleic, α-linolenic and arachidonic acid significantly increased. The long term replacement of marine ingredients by vegetable oils and plant protein sources does not impair Senegalese sole growth, but strongly reduces EPA+DHA muscle levels compromising the nutritional value of those fillets for human consumption. A finishing diet able to restore the fillet fatty acid profile could be a good strategy to provide the recommended daily intake of omega-3 for healthy human individuals.

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Nutritional effects on dark fillet spots of Atlantic salmon (Salmo salar L.)

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Dark spots of salmon fillets cause quality downgrading to cheaper products or removal from the food chain. Statistics from the Norwegian farming industry document an increased frequency from 5% in 2005 to approximately 20% at present. Hence, dark fillet spots represent the greatest and most costly quality deviation of salmon fillets at present.

The spots are typically greyish-black 3-6 cm wide, and the belly part is the most seriously affected area. Because the spots are hidden under the ribs, they appear only after filleting and trimming, and cannot be detected by inspection of whole fish. The black color is associated with melanin pigments, and the discolored tissue is characterized with accumulation of melanomacrophages, occasional formation of granulomas and substitution of skeletal muscle with connective tissue. The underlying cause of the dark spots is unknown, but there is significant evidence that dietary composition affects both the amount of fillets with dark spots, and the size of the spots of affected fillets.

Salmon reared under commercial production conditions showed significantly lower frequency of dark spots when they were fed high protein/low fat diets. However, upregulation of genes associated with melanin deposition in salmon fed certain protein raw materials indicate that cautions should be paid when new feed ingredients are considered. The fatty acid composition also seems to affect dark pigment deposition. A large scale study revealed that salmon fed a diets rich in eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) had fewer fillets with dark spots (Sissener et al. 2016), and supplementation of DHA rich algae likewise caused a significant reduction in the frequency of dark fillet spots. We have shown that dietary supplementation of certain antioxidants (Vitamin E, C, and Se) can reduce dark pigment deposition. Extra zinc and inclusion of krill meal have also shown a certain reduction, while high level of copper can cause a marked increase.

It is concluded that dietary composition significantly affects the frequency and the size of dark spots of salmon fillets. When new ingredients are supplemented to salmon diets, it is important to assure that they don't compromise the fillet appearance.

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FORMULATED PACIFIC BLUEFIN TUNA DIETS IMPROVE FLESH QUALITY AND INCREASE SHELF LIFE OF SASHIMI-GRADE PRODUCT

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The tuna ranching industry is a global, high-value aquaculture activity. Current feeding practices are impractical, unsustainable and pose serious ecological risks. The daily feeding of copious quantities of fresh/frozen fish results in extremely high feed conversion rates (~28 : 1). Seasonal availability and quality variation of locally sourced baitfish highlight the need of a balanced feed. Objectives for the present experiment were to compare performance and quality indicators of Pacific bluefin tuna (PBFT, Thunnus orientalis) fed sardines or a compound feed.

A seventeen-week feeding trial was conducted in two oceanic net pens moored east of Coronado Island (BC, Mexico, 32o24'48.80" N; 117o13'70.10' W). Each cage held ~440 fish, weighing approximately 50 kg (average initial individual weight, assessed by AQ1's AM 100 fish sizing system). Feed consumption and condition factor were recorded. A first sampling effort was conducted at week 6. Dorsal loins were collected and color, mercury, proximate composition, scombrotoxin levels, oxidative stability index and peroxide values were evaluated in the resulting steaks. In addition, a blind sensory evaluation and a commercial taste assessment were performed on the main sashimi cuts obtained from fish fed either diet.

Steak samples from formula-fed fish had lower lipid contents but improved color, texture and had increased oxidative stability and reduced histamine. Results from sensory and organoleptic evaluations (professional sashimi chefs) indicated that sashimi slices from formula fed fish were similar in flavor but more stable on the counter and superior in color.

In addition, the formulated diet offered feed management options that were quite compatible with the present operation and equipment available at commercial tuna farms. A preliminary economic evaluation (2017 prices) indicated that tuna feed is more cost-effective than frozen baitfish but more expensive than fresh sardine. Given the current forecasts for the Pacific sardine fishery in Southern California, the formulated diet may offer a viable alternative to baitfish feeding. In conclusion, these results indicate that the balanced feed provided suitable nutrition for adult tuna, enhanced the quality and shelf life of the final product and may enable

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Effects of Storage Conditions on Peroxide Values of Commercial Fish Oils

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Unsaturated fatty acids of fish oils are easily oxidized and degraded by the combination of atmospheric oxygen with heat, light and the catalytic effect of some heavy metals. Oxidized oils cause odor, color and flavor disorders in feeds. The oxidation process is complicated and in the first stage hydroperoxides, peroxides and then peroxide polymers are formed. The peroxide value (POV) is very important in fish oil and it is not desirable to exceed 20 meq/kg. Storage of feeds containing fish oil at high temperature results in an increase in both oxidative and hydrolytic rancidity with a loss in feed quality. The aim of this study is to determine the POV of different fish oils depending on the storage time and conditions.

Oil samples were obtained from companies that produce fish oil in Turkey and companies that sell to the fish feed sector. Oils used in the trial; Black Sea fish oil (anchovy + Sprat mixture), Sprat oil, Anchovy oil, Norway Fish oil, Aquaculture by-products oil, Som by-products oil. These oils were stored at room temperature (20 C0), refrigerator (4C0) and at 30 C0 to represent higher temperatures. Storage times are 60 days. Fish oils are divided into three groups according to the storage temperature, each group being arranged to be 3 repeated. Peroxide values (POV) were made according to the AOAC 965.33 titration method.

Norwegian fish oil initially having the lowest peroxide value (1.87 meq) among the fish oils stored at high temperature reached the highest POV (24.47 meq) at the end of the experiment. POV in all fish oils kept in the refrigerator did not show much change compared to the initial POV. There are acceptable increases in POV depending on the storage period (Table 1).

The number of peroxides in oil increased with increasing temperature and storage period. When the results are evaluated according to the storage period, it is determined that at 20 and 30 CO at the end of the 2nd month, many fish oils have acceptable levels of peroxide in the vicinity and some of them are in a state of rancidity.

Effect of modified atmosphere packaging on microbiological and Physico-chemical properties of microencapsulated diet

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The microencapsulated diet for shrimp larvae was prepared by the ionic crosslinking method with calcium and sodium alginate solution. After the process completion, the raw materials were entrapped in a sponge-like matrix of Ca-alginate. Microbiological analysis (total plate counts) and physico-chemical properties [pH, coloration retention, flowability (angle of repose), lipid oxidation (Thaiobarbituric acid reactive substance, TBARS)] of microencapsulation diet in air (non-MAP) and modified atmosphere packaging with nitrogen (MAP) at 25±1 ๐C for 90 day were determined. The samples intended for storage in MAP were flushed with nitrogen gas for 10 second and the aluminium foil bags were sealed immediately. The non-MAP was sealed without a modified atmosphere in the bags. Total bacteria count was 1.57±0.24 x 104 cfu/g on the MAP. However, it was significantly lower in samples packaged with non-MAP. A slight increase in pH was observed with increasing storage time but no significant difference among the groups. The pH value of the diet storage under non-MAP and MAP was 5.51±0.04 and 5.51±0.05, respectively. Concerning coloration retention, a* was significantly higher in diet storage under non-MAP than MPA while L*and b* were not significantly different under different storage conditions (P>0.05). Oxygen contained in non-MAP had a significant effect on a* values of the samples. A slight decrease in the L* value was observed with increasing storage time and the b* value strongly increased up to 22 when stored for 90 days. About flowability, the non-MAP sample showed higher flowability than the MPA. The angle of repose was 32.60±0.83 and 30.34±0.87 after the storage test. Lipid oxidation measured as TBARS value, it was significantly higher particularly under Non-MPA than MPA (P<0.05) and the TBARS value of all groups increased during storage. At 90 days of storage, the data was 0.783±0.07 and 0.62±0.03 µmol per kg sample.

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ASSESSMENT OF DIFFERENT PROTEIN/LIPID RATIOS IN DIETS FOR SEA URCHIN, Paracentrotus lividus

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Paracentrotus lividus gonads are considered a prized seafood delicacy due to its flavor and texture. The increasing market demand for sea urchin depleted wild stocks, leading to its aquaculture production. But the nutritional requirements of this species remain to be evaluated. Four extruded diets were formulated with two protein (30 and 50%) and two lipid levels (6 and 11%) and fed to sea urchins harvested in an intertidal zone of Portugal for 15 weeks. Twelve homogeneous groups of 15 individuals (35 g; 4.5 cm diameter) were distributed by plastic mesh cages (45 urchins/m2) within 250L tanks in a saltwater recirculation system (salinity 35‰, 18ºC) with a 12hL:12hD photoperiod regime. At the end of the trial, individuals from the same wild spot were collected for gonad comparison.

All experimental diets were well accepted by the sea urchins and final body weight remained similar among dietary treatments (42-43 g). No significant differences were observed in daily growth index or protein efficiency ratio among diets. Increasing dietary protein level significantly decreased dry matter and energy intake, and reduced feed conversion ratio (FCR).

The gonadal somatic index (GSI) was high and similar among dietary treatments (21%), and much higher than average values observed in wild specimens (6%) at the same maturation stage. The gonads of females were significantly higher and had a lower protein, but higher lipid content, than males. Gonad total carotenoid concentrations were unaffected by the diets being always higher in females. The tested diets did not affect gonad texture (firmness and resilience) and color parameters (brightness, redness and yellowness), but wild species gonads showed higher redness and firmness values, irrespectively of the genre.

This study shows that it is possible to enhance sea urchin gonad size in relation to wild individuals in a RAS at 18ºC. All diets induced similar growth, but the high protein:low lipid diet had the lowest FCR. Future studies are required to adjust gonad quality (color and texture) to consumers preferences.

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Effects of dietary components on absorption and retention of astaxanthin in Atlantic salmon (Salmo salar L.)

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In recent years, there has been some problems with achieving sufficient flesh colour in Norwegian farmed salmon. The gradual reduction cannot be ameliorated by adding more astaxanthin in the diets. Salmon diets have gone through major changes the last decades from essentially a marine based diet with a protein/fat ratio of 3:2 in the early 90s to a diet with 70% plant ingredients and a protein/fat ratio of approximately 1:1 today. This shift in ingredients has resulted in reduced levels of the omega-3 FAs EPA and DHA, and increased pro-inflammatory omega-6 FAs content in organs and tissues. High fat diets with 70–80% plant ingredients also increase whole body lipid retention and lipid concentrations in the liver of Atlantic salmon when additional marine micronutrients are not added. The possible effects of such dietary changes on absorption, metabolism and flesh retention of astaxanthin were tested in a controlled experiment in tanks using a 2x2 factorial design with replacement of fish meal (FM) and fish oil (FO) with plant protein (PP) and plant oil (PO).

200 g Atlantic salmon were fed a marine-based diet (FMFO), a plant-based diet (PPPO), a diet with PP and FO (PPFO), or a diet containing FM and PO (FMPO). The plant-based diet (PPPO) was supplemented with concentrates of DHA and phospholipids to study potential effects of these lipids on astaxanthin absorption and retention. Lipoproteins and liver cells were isolated from selected diets to study transport and metabolism of astaxanthin. The results from the study show that diets with PP led to reduced feed intake and growth, most likely due to reduced fat absorption. Absorption of astaxanthin was also reduced in low FM diets, but addition of phospholipids increased absorption of astaxanthin and fat. However, astaxanthin retention in the fillet is dependent on both absorptive and post-absorptive processes such as metabolism of astaxanthin in various organs. The concentration of astaxantin metabolites in fillet and liver were affected by diet composition, and analysis is still ongoing to elucidate the processes involved.

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Sensory quality of Atlantic salmon (S. salar) fed no fish meal–no fish oil diets

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An ultimate goal in the farming industry is to become independent of fish meal and fish oil in aquafeeds. In recent years, commercial diets without fish meal have become available, but complete substitution of fish oil has been difficult due to lack of alternative sources providing the long-chain n-3 fatty acids (LC n-3 FA) required by salmon during the grow-out phase (Rosenlund et al., 2016). However, with the current developments of new oil sources rich in LC n-3 FA, this can change.

The aim of the present study was to test the effects of feeding diets containing no fish meal and no fish oil on performance and product quality of Atlantic salmon. Triplicate groups of fish of ~1kg were fed 3 different diets till they reached a harvest size of ~6 kg. The trial was conducted at Skretting ARC Lerang Research Station in 3 m tanks supplied with flow through seawater at 12°C. Two test diets containing no fish meal were added two levels of algal oil (Veramaris ®) as a source of EPA and DHA, at either 2-4 % or 8-15 %. The control diet contained 15 % fish meal and 7.5-12.5 % fish oil to mimic typical commercial diets (Norway) for salmon of similar fish sizes. At the end of the growth trial some fish were sent to Nofima AS (Ås, Norway) for sensory evaluation of raw and cooked fish. The sensory tests were carried out by a trained panel consisting of 11 judges according to ISO 13299:2016. Fish were scored on a scale from 1 (low) to 9 (high) using the software EyeQuestion and EyeOpen® (both Logic8 BV, Wageningen, The Netherlands) for attributes related to appearance, smell, flavour and texture.

Growth was good (Relative Growth Index ~100 %) and similar, independent of diet. Sensory evaluation of raw and cooked salmon showed no or only minor differences between dietary treatments. Thus, Atlantic salmon can be fed diets without fish meal and fish oil for most of their grow-out period in sea without negative impact on performance and product sensory characteristics.

Fish nutrition role in sensory quality traits of final products and consumer preferences

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Nutrition is one of the critical elements required to maintain production efficiency, enhance animal health, decrease nutrient waste, and improve the economic viability of any animal production system. Additionally, nutrition plays an essential role in achieving the satisfaction of consumers' needs because feed composition will directly affect the final product quality. Animal nutrition and feeding are crucial in any livestock production system, including aquaculture. It is essential to evaluate the effect of changing aquafeeds formulation and composition on the bromatological characteristics of the final products, since resulting organoleptic properties are a direct consequence of such modifications. These properties will be part of the key quality attributes that could determine the consumer's acceptance. In this context, it is possible to state that properly applied sensometrics play an essential role in any study related to changes in the feed composition and nutrition of aquaculture species. Sensory analysis can be applied to do an objective assessment through the use of a trained assessor's panel to obtain quantitative data which could be correlated with any other analytical parameters or to perform a subjective evaluation applying hedonics and affective (emotional) tests in consumers to know and understand their opinion adequately. The design and development of any nutrition and feeding experiment, which include sensory evaluation methods should be established and planned considering the primary objective and available resources for the study. This work aims to provide an overview of the current state-of-the-art sensory methods and to analyse the impact that nutrition and feeding have on the sensory characteristics of farmed fish destined for human consumption.

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Effects of dietary protein level and non-protein energy source on muscle growth mechanisms in rainbow trout (Oncorhynchus mykiss) juveniles

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Muscle growth, the main determinant of fish growth, is the result of two mechanisms: hyperplasia (recruitment of new muscle fibres) and hypertrophy (growth of existing fibres). The regulation of fish muscle hyperplasia and hypertrophy by changes in dietary macronutrient composition has been little documented. This study analyses the effects of dietary digestible protein to digestible energy (DP/DE) ratio and non-protein energy (NPE) source on muscle growth mechanisms in rainbow trout juveniles by using cellular and molecular approaches. The four diets had identical DE levels with a high vs. low DP/DE ratio using 'F, fat' or 'C, carbohydrate' as major NPE (HP/EF, HP/EC, LP/EF, LP/EC). They were fed to rainbow trout juveniles for 7 weeks. At high DP/DE ratio, the protein growth was unaffected by NPE source. At low DP/DE ratio, protein growth was higher when NPE source was fat. Compared to control (HP/EF), the gene expression of MyoD1 and Mrf4 was increased in LP/EF-juveniles, that of CathD increased in HP/EC-juveniles, and that of fMHC and fMLC2 decreased in LP/EC-juveniles. A lowering of DP/DE ratio decreased the gene expression of Mstn1b whatever the NPE source. Feeding the HP/EF-diet led to the highest total cross-sectional area of white muscle (TCSAWM) and total number of white muscle fibres (TNWF). Both were decreased, for each DP/DE ratio when NPE was carbohydrate, and for each NPE source when DP/DE ratio was low. The LP/EC-trout had the lowest TCSAWM and TNWF. Changes in diet composition also induced changes in white fibre growth dynamics. At high DP/DE ratio, the replacement of fat by carbohydrate decreased the percentage of small fibres and the maximum fibre diameter. At low DP/DE ratio, the replacement of fat by carbohydrate had no effect on the percentage of small muscle fibres but decreased the maximum diameter of muscle fibres and the percentage of large fibres. Our data thus indicate that a combination of low DP/DE ratio and carbohydrates as NPE strongly impairs white muscle growth, due to decreased hyperplasia and hypertrophy, while a combination of high DP/DE ratio and fat as NPE stimulates both hyperplasia and hypertrophy, leading to high muscle growth.