

By-catch and offal feed from the herring industry • performance of Atlantic salmon as concerns growth, feed utilisation and fillet quality.

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In the beginning of last decade (1991) the idea and research on heat-coagulated feed, produced mainly from offal from the pelagic fishing industry, started. The objective was higher/better economic utilisation of, at that time, a low-cost product. Freshly produced offal was evaluated chemically and found to be rich in protein, lipid (with large parts of highly unsaturated n-3 fatty acids), vitamins A and D, several minerals, and with ash contents quite low (10-12%). Protein quality was evaluated by analyses of volatile nitrogen and mink-digestibility, and fresh offal was found to hold LT-fish meal quality, while stored offal rapidly lost quality. The on-line production technique of growers feed for the salmon industry started. During the decade several research projects, each including several fish experiments, was carried out. Some results from two of the experiments will be presented in this conference.

In experiment 1 Atlantic salmon (*Salmo salar*) was fed heat-coagulated moist feed throughout one year. Dietary regimes were as shown in Figure 1.

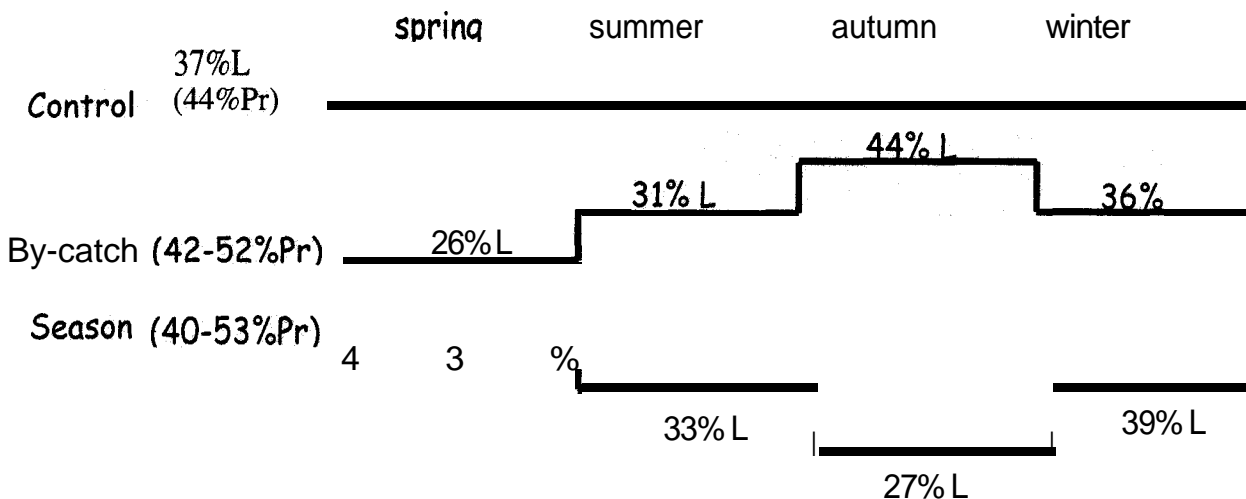


Figure 1. During the one year experiment three sea-cages of Atlantic salmon were fed a control feed holding 37% lipid (L) and 44% protein (Pr). The protein held LT-quality. Another three cages (By-catch group) were fed for 3 months with a lean diet (26%L), made on spring catches, without additions of lipid or protein, as the lipid content increased in the pelagic resources during summer, a switch to 31%L-holding feed were done during the 3 summer-months, further a diet holding 44% L were fed during the 3 autumn months, and again a lean diet during the 3 winter months. This group simulated by-catch composition / herring offal during the year. The Season group (3 cages) was designed oppositely to the By-catch group, using a lipid rich spring feed (43% L), summer = 33% L, autumn = 27% L, and winter 39% L.

The aim of this experiment was to evaluate if the main raw material used in this pilot-industry (herring or other pelagic fish) could be used as such without balancing the macronutrients to be equal throughout the year. Further if there would be any gain in tailoring the on-growing feed to meet the Atlantic salmon's natural yearly rhythm as concerned energy deposition / utilisation.

All groups grew well and according to commercial standards during all seasons, but the final average live weight after 1 year in sea was 0.5 kg higher in the Season tailored group compared to the

By-catch group. Average weight at start was 1.8 kg for all groups, ending at 7.4 kg in the By-catch, 7.6 kg in the Control and 7.9 kg in the Season tailored group. Averagely less than 1 kg dry feed was needed to produce 1 kg fish, except for the By-catch group during the spring period, where we concluded that the feed was to lean for maximum feed utilisation. A high positive correlation was found between growth rate, feed utilisation and protein retention, and PPV (protein productive value) varied according to season and feed composition. Retention of protein was from 30 to 53%. The high growth obtained in addition to no mortality during the experiment indicated good fish health. Additionally organ function was evaluated by measuring ASAT (asparagine aminotransferase) and ALAT (alanine aminotransferase) in plasma, which showed low levels in all groups at all samplings. Leakages of these enzymes to plasma (increase in concentrations) are among the first indicators of decreased organ (liver) function. Haematological evaluation of blood samples (Hct, Hb, Rbc) further underlined the good fish health. Additionally healthy values of plasma nutrients were detected in all groups at all samplings. As concerned product quality, the present experiment confirmed earlier findings that there was a high correlation ($r^2=0.53$, $p < 0.05$) between dietary lipid and lipid retention, which, however, was partly masked by an even higher correlation ($r^2=0.73$, $p < 0.05$) between fish size and lipid retention. If selection of one size of fish were done, the diet was the main factor influencing lipid concentrations, as also published by Hemre and Sandnes (1999). Incorporation of vitamin E in muscle was efficient in all groups at all samplings.

In another experiment three dietary groups were fed in triplicate this new type of feed for 3 months. Groupings were low (31% L), Medium (38% L) or High (47% L) dietary lipid levels, constant protein, and starch balanced towards the variations in lipid. Apparent digestibility coefficients for lipid and starch decreased as dietary starch increased and dietary lipid decreased. No effect was found on protein digestibility. By holding exact control on feed intake, calculations could be made on how dietary compositions affected out-let of undigested matter. Per kg salmon produced a total of 350 g total outlet (lipid + starch + nitrogen) was produced when given the low lipid / high starch diet, the amounts of out-let decreased as lipid levels increased and starch levels decreased, and only 80 g total out-let was found when given the high-lipid (47%L) plus low starch (7%starch) diet.

Conclusions:

High growth rates are obtained when feeding Atlantic salmon heat-coagulated feed produced directly from wet minced marine ingredients without additions of fish meal or fish oil. Additionally, this kind of feed results in high feed utilisation and protein retention. Using this feed for the on-growing stages in Atlantic salmon production leads to no negative effects as concerns fish health registered by no mortality and normal ranges of haematological parameters and plasma enzymes. There might be a positive effect on growth rate by tailoring feed composition to season. Variations in lipid to starch ratio highly influence the digestibility coefficients, and thereby also the amount of out-let of undigested material to the surroundings.