International Fishmeal & Oil Manufacturers Association

FRESHNESS OF FISH USED IN MAKING FISH MEAL FOR SALMONIDS AND THE EFFECTS OF BIOGENIC AMINES

Report of a Trial by the Icelandic Fisheries Laboratory

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EXECUTIVE SUMMARY

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Background

The freshness of fish used to prepare fish meal has been found to affect the growth of salmon to which it is fed (see Research Reports 1991-2 and 1993-3). Using fish that was either fresh, moderately fresh or stale, fish meals were prepared for two salmon growth trials - carried out in Scotland - one using herring, the other anchovy. The former fish meal was prepared in Norway, the latter in Chile.

With European (herring) and South American (anchovy) fish meal salmon grew more slowly when fed those manufactured from stale raw material. Although it is difficult to measure feed intake of fish in feeding trials, an estimate was made in both trials. Using a combination of automatic feeding early and late in the day, and in between, careful feeding to appetite by hand to fish in shallow tanks, an estimate of feed intake was made. In the trial with herring meal, intake was significantly reduced with the stale fish meal. This may have resulted in most or all of the reduced growth rate. In the trial with South American meal, an effect of freshness on feed intake was not found. Growth was reduced with the stale fish but to a smaller extent than in the first trial. It is believed that biogenic amines may have caused the growth depression, but the differences between the two trials may have been due to chance or to the presence of different levels of amines, or other spoilage compounds which reduce growth.

Further confirmation of the effect of amines in depressing growth has been found in trials undertaken by the Icelandic Fisheries Laboratory. They found that acidification of feed with hydrochloric acid reduced the deleterious effect of amines on growth. These trials are reviewed in their report which follows.

It was recommended by the Scientific Committee that the effects of individual biogenic amines on feed intake of salmon should be investigated systematically. In view of their past work with amines and their facilities for working with fish, the work was contracted to the Icelandic Fisheries Laboratory. The main points from their report follow.

Association Trials to Investigate Effects of Biogenic Amines on Feed Intake at the Icelandic Fisheries Laboratory

Because of feed loss from the cage or tank it is difficult to measure feed eaten. Thus x-ray procedures have been developed to measure feed in the intestine of fish using glass beads to mark the feed.

One member of the research team from Icelandic Fisheries Laboratory had worked with the x-ray procedure as part of a group in Norway that had extensive experience of these procedures. In addition, the Icelandic team had developed another procedure based on an n-alkane marker. Intake was determined by measuring the marker in faeces following feeding of the feeds in which the marker was incorporated. The digestibility of the treatment feeds had previously been determined in salmon. By dividing faecal output by digestibility, intake was determined. In addition, fish reared in tanks were fed the treatment diets and their growth measured.

The amines to be studied were tyramine, putrescine, cadaverine and histamine. The trial was originally planned to prepare fish meal from fresh capelin, and from the same fish after it had been allowed to go stale, and to add amines to the former. Due to planned part financing of the trial by the Icelandic Research Council not going ahead, the production of experimental fish meals had to be abandoned to save costs. Instead, a commercial fish meal made with fresh capelin was obtained but the stale fish meal was omitted. The four biogenic amines were added to this fish meal together or in groups of three, that is, systematically omitting to add one at a time, as originally planned. The amounts added were based on levels typically found in fish meals made from stale capelin.

The six treatments employed enabled the effects on feed intake of each of the four amines in turn to be compared with one another, in the presence of other amines which may have had a potentiating effect. A comparison of the results from meal prepared from fresh fish plus all four amines against fish meal from stale fish where amine levels were equated was not possible.

The Results

Neither method of measuring feed intake, x-ray nor n-alkane marker, showed significant differences between treatments, and growth rates did not differ significantly either. (There was a numerical trend for both feed intake and growth to be lower when amines were added.) These results appear to contradict earlier trials in Iceland where growth was depressed with amine addition, and also the Association's trials with fish meal made from fish of different freshness, referred to earlier. Careful consideration has been given to possible reasons for these apparently contradictory results.

Some difficulties were experienced in determining amines in the diets to confirm correct amounts had been added. The results obtained from outside laboratories indicated that the addition of amines was correct. Consequent to the difficulties arising with amine analysis in this trial, the Association has set up a collaborative trial to assess methods of amine analysis conducted at different laboratories.

Discussion

The failure to differentiate between biogenic amines in their effect on feed intake may have been due to high variability between individual fish and/or the use of formic acid

to get the amines into solution to facilitate mixing them into diets. Also, problems were encountered with accuracy of amine analysis.

It would appear in hindsight that feed intake should have been measured on several occasions with the same fish to reduce fish variability in intake by individual fish. Although formic acid treatment of amines was not expected to alter feed intake, previously an effect had been noted with hydrochloric acid, a strong acid. Although formic acid is relatively weak, it was felt it could have affected the results.

The failure to show significant growth differences due to the amines may be due to the slow growth of the fish - differences may be more pronounced with faster growing fish. According to Norwegian growth tables (see Technical Bulletin number 25, p.30) growth rates achieved there around five years ago would typically have been double (2.8% per day) that achieved in the trial (1.1 to 1.4% per day).

The Icelandic group suggest that the heavier initial weight of the fish in this trial (22g) than in their earlier trial (2g) may have been responsible for the no-difference result because the former may be less sensitive to amines.

The possibility that amines other than the ones tested, or other compounds formed by microbiological spoilage of fish such as endotoxins, for example, might affect feed intake, cannot be ruled out. The treatment comparison that might have thrown more light on this, meal made from stale fish v fresh fish meal plus four amines, was not possible.

Recommendation

In view of the importance to the fish meal industry of knowing the relative effects of amines on feed intake and growth of salmon, it has been recommended by the Scientific Committee that this work should be repeated. Emphasis should be placed on growth, to work with fast growing salmon. If possible feed intake should be measured, to be done on several days at intervals over the growing period.

Icelandic
Fisheries Laboratories

Feed Intake, Digestibility and Growth Trials with Salmon (*Salmo salar L.*) Parr: Effects of Biogenic Amines in Feeds.

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ABSTRACT

The experiment was carried out to find out if feed made from capelin meal with high concentration of biogenic amines reduces appetite (feed intake), utilisation (apparent digestibility) or causes toxicity and therefore reduces growth when fed to salmon parr. Synthetic biogenic amines in concentration found in capelin meal from stale raw material was incorporated into high quality capelin meal. Two methods were used to measure feed intake i.e. by radiography and using n-alkanes as markers. Radiography was used both at the end of 79 days growth trial and in 70 l tanks (Guelph digestibility system) at the end of a 7 days faecal collection for an apparent digestibility and intake study using n-alkanes.

Incorporation of the synthetic biogenic amines did not result in significant differences in feed intake, apparent digestibility or specific growth rate of the salmon parr. Large individual variation was observed in the radiography feed intake study.

Reykjavík, Iceland in May 1994

INTRODUCTION

Experiments were done on feed intake, digestibility and growth rate of salmon parr fed high grade capelin meal based diets with added synthetic amines. The amount of biogenic amines added was similar to the concentration found in earlier studies on capelin meal with Total Volatile Nitrogen (TVN) of 120 mgN/100g in raw material. In that study capelin with TVN value of <50, 90, 120, 175 mg N/100 g and total biogenic amines in the meal 130, 171, 364 and 631 mg/100 g respectively was tried in salmon feeds in order to determine specific growth rate of salmon fry for 160 days when fed the different meal qualities (Tryggvadóttir et al., 1990, Tryggvadóttir et al., 1993). Result from another study gave a significant difference in specific growth rate and feed conversion when feeding salmon smolts (90 g) in sea water for 84 days, on different quality of herring meal based diets, fresh TVN 22 (total amines 400 ppm), moderately fresh TVN 62 (total amines 2070 ppm) and stale TVN 143 (total amines 3860 ppm) (Pike (1991).

Two approaches were used to measure feed intake i.e. a radiography method (McCarthy et al., 1993) and a n-alkane marker based method (Guðmundsson and Halldórsdóttir 1993). Three separate feed intake studies were performed. A Guelph digestion tank system (Cho et al., 1982) was used for two feed intake experiments. One was done using n-alkanes as indigestible markers and settling columns to collect faecal samples, to determine faecal output and digestibility for intake calculation and the other was done using ballotini glass bead labelled feed followed by X-radiography to determine the feed intake. A third feed intake study was done in regular 1 m^3 fibre glass tanks, using glass beads and X-radiography, following a 79 days growth trial.

MATERIAL AND METHODS

Fish

Four thousand salmon parr from a salmon farm in Kollafjördur, Iceland were used in the experiments. The parr were of mean weight 20 g (± 3), and had prior to the transport been fed in 12 m^3 tank on a commercial feed (Ewos ST40, 2mm).

Feed intake and digestibility experiment in the seventy litres tanks (Guelph digestibility tanks)

The salmon parr were adjusted to the Guelph digestibility system (Cho et al., 1982), for 3 weeks prior to the start of the experiment. Six kg salmon parr (mean

weight 22 g) were kept in each unit, but three tanks are connected into a unit i.e. 2 kg fish were in each tank of 70 litres, giving a density of 28.6 kg/m^3 in each tank. Each tank has its separate water inlet and outlet with a constant flow of fresh water that was not recirculated. The water temperature was held at 15 °C. In the morning the fish in each tank were fed an exact amount (5 g) of experimental feeds labelled with C_{32} alkanes. It was made certain that every pellet of this 5 g was eaten. After the C_{32} labelled feed had been fed, feed with C_{36} alkanes was hand fed ad libitum four times a day. At the end of the working day the tanks and the faecal settling columns were thoroughly cleaned. Next morning the faeces were collected from the settling columns. This feeding and faecal collection pattern continued for seven days, but previous to that the fish had been fed similarly for a preliminary period of five days without faecal collection. The faecal samples were pooled for each feedstuff. After this seven day period the experimental feeds were randomly changed to different fish tanks, then the fish were adjusted to the different experimental feed for a week followed by a replicate feeding and faecal collection period for another week. Following each seven day faecal collection period feed intake was measured by radiographic method. In the morning the fish were fed the same feed except labelled with X-ray sensitive glass beads. Seventeen hours had passed since the last feeding the day before. The fish were fed ad libitum, with small intervals, for three hours. Thirty fish from each test tank were killed with anaesthetisation (benzocaine spiritus) and X-ray photographed. The X-ray films were developed and the number of glass beads in the gastrointestinal tract of the fish counted and the weight of feed ingested calculated with reference to a calibration curve determined for the relationship between the dry weight of feeds against the number of glass beads.

Growth trial and feed intake study in the one square meter tanks

Fiber-glass tanks of one square meter with a constant fresh water flow through the system were used in the growth trial experiment. Each tank contained 125 salmon parr, with initial average weight of 22 g and two replicates. Feed was offered continuously for 24 hours in accordance to commercial feeding tables (EWOS, 1992), using automatic disc feeders. The feeders were set to revolve one circle in 48 hours with feeding every 30 minutes. The density in the tanks was kept at 10-15 kg/m^3 throughout the trial, by increasing the water column as the trial went on and the parr grew.

The water temperature was held at 14 °C. The growth trial lasted for 79 days. At noon, on the last day of the experiment the experimental feed was replaced with the same feed containing X-ray sensitive glass beads. Ten hours later 25 % of the fry (30

individuals) from each tank were killed with anaesthetisation and X-ray photographed. All fish in the tanks were individually weighed.

Experimental feeds

The same basal compound feed was used for all the experimental rations, except for the biogenic amines which were as follows:

Capelin meal	77.2 %
Extruded wheat	11.0 %
Capelin oil	10.0 %
Vitamin and minerals	1.8 %

High grade capelin meal was used in the experimental feeds with TVN value of 20 mgN/100g in raw material. Synthetic biogenic amines as free base was added to the meal (feed) to give the following concentration:

tyramine	128	mg/100 g	meal	(99 mg /100g feeds)
putrescine	148	"	"	(114 mg/100g feeds)
cadaverine	241	"	"	(186 mg/100g feeds)
histamine	20	"	"	(16 mg/100g feeds)

See table 2A and 2 B for biogenic amines analysis of the feeds.

Six test feeds were made:

1. Capelin meal made from fresh raw material (TVN 20 mgN/100g).
2. Capelin meal from fresh raw material (as in 1) with added tyramine, putrescine, cadaverine and histamine.
3. Capelin meal made from fresh raw material (as in 1) with added tyramine, putrescine and cadaverine.
4. Capelin meal made from fresh raw material (as in 1) with added tyramine, putrescine and histamine.
5. Capelin meal made from fresh raw material (as in 1) with added putrescine, cadaverine and histamine
6. Capelin meal made from fresh raw material (as in 1) with added cadaverine, tyramine and histamine.

Each amine combination (tpch, tch, tpc, tph, pch) was dissolved in: 50 ml formic acid (30%), 80 ml water and 280 ml propylene glycol (an inert carrying agent). After complete dissolution the mixture was sprayed into the dry feed mixture while it was rotating in a mixer.

The n-alkanes C_{32} and C_{36} were dissolved in fish oil after which they were sprayed in the feed mixture while mixing. C_{36} was incorporated into the whole feed mixture, few kg where taken out into which C_{32} was also added. The incorporation level of each n-alkanes was 50 g /100 kg dry matter.

The opaque glass beads markers (Ballotini size 8.5:400-450 µm diameter; Jencon´s Ltd., Leighton Buzzard) were incorporated at a level of 0,8% dry material, which was the amount found to be the prime level in a small experiment done at the Agricultural Research institute in Iceland, on optimum amount and sizes of glass beads for X-ray detection, in different sizes of feed pellets (Th. Pétursdóttir, personal communication).
The X-ray instrument used was Andrex X-ray tube CMA 165, Andrex control unit CMA 402.F, AGFA D7 pb film (the lead in front was removed). Distance (FFD) 100 cm, 3.0 mA (75 sec exposure time; 50 kW). Lead sheet of 2 mm thickness was beneath the film while exposed.

The last step in the experimental feed production was pelleting the feed into 2mm pellets with a pilot plant pelletizer.

Sample preparation and analysis

Feed samples were processed directly whereas the faecal samples were freeze dried. Dry matter was determined and all samples were ground and analysed for the proximate ingredient in accordance with AOAC (1990). In the n-alkane analysis the samples were directly saponified in alcoholic KOH and the alkanes extracted in heptane, after which they were passed through silica gel making them ready for gas-liquid chromatographic determination (Gudmundsson and Halldórsdóttir,1993). The biogenic amines in the feed were analysed using the HPLC procedure (Torry Research Station, Scotland and IFREMER, Centre de Nantes, France).

Analysis of gowth

Specific growth rate (SGR) was calculated according to (Ricker, 1979):

$$SGR\ (\%\ day) = (\ln(w2)-\ln(w1))/\ t*100$$

where w1 and w2 were the measured initial and final weights, respectively after t days (79).

Calculation of digestibility and feed intake

The calculations of the results from the n-alkane based approach, were done according to Guðmundsson and Halldórsdóttir 1993.
The apparent digestibility was calculated according to the following formula:

$$\text{Apparent digestibility of nutrients in \%} = 100 - 100 \times \frac{\text{\% nutrients in faeces} \times \text{\% } C_{36} \text{ in feed}}{\text{\% nutrients in feed} \times \text{\% } C_{36} \text{ in faeces}}$$

The faecal output was calculated as:

$$\text{Faecal output} = \frac{\text{Amount of } C_{32} \text{ consumed}}{\text{Concentration of } C_{32} \text{ in faeces}}$$

and finally the consumption was determined from the equation:

$$\text{Intake} = \frac{\text{Faecal output}}{1-(\text{Digestibility}/100)}$$

Statistical analysis

Statistical analyses were performed using the Number Cruncher Statistical System (NCSS, 1987). Analysis of variance was done using the GLM-Anova package within the NCSS.

RESULTS AND DISCUSSION

The proximate analyses and the pH of the experimental feeds is shown in table 1. The proximate anlysis of the six individual feed mixtures compare very well.

Table 1. *Approximate analyses and pH of the experimental feeds.*

Trial feeds No	Biogenic amine labelled feeds	The proximate analysis of the feed on dry matter basis			
		Protein (Nx6,25)	Fat	Ash	pH in feeds
		%			
1	Control no amines added	62.3	20.9	10.3	6.8
2	Tyr, Put, Cad, Hist	61.7	21.5	10.5	6.9
3	Tyr, Put, Cad	62,4	20.5	10.5	6.9
4	Tyr, Put, Hist	62.2	20.9	10.5	6.7
5	Put, Cad, Hist	62.3	20.8	10.4	6.8
6	Tyr, Cad,Hist	62.0	21.1	10.4	6.7

Tables 2A and 2B show the biogenic amines analyses on the experimental feeds. The amount of histamine in the feeds is lower than expected. However it is well known that the level of histamine is low in capelin meal even in meal of low quality (Magnúsdóttir and Möller, 1986). In an experiment on freshness of herring for fishmeal it was found that TVN value of 62 mgN/100g in raw material gave meal with histamine content of 44 mg/100 g (Pike, 1991). The histamine concentration aimed for in this experiment ((20 mg/100 g (16 mg/100 g feed)) to imitate the amount of histamine concentration in stale capelin meal is thus close to half the amount found in moderately fresh herring of TVN value of 62 mgN/100 g. Therefore it is very likely that the concentration of histamine in capelin meal from stale raw material is of little importance. The biogenic amines were analysed at two different laboratories. The results are shown seperately in tables 2A and 2B indicating a poor accuracy for biogenic amine analysis by the HPLC technique. The difference between expected and measured concentration of histamine can possibly be explained by the relatively high analytical inaccuracy.

Table 2A. *Analysis of biogenic amines in the experimental feeds analysed by the Torry Research Institute in Scotland.*

Trial feeds No	Biogenic amines added to feeds	mg amine free base/100 g feeds as is				Total biogenic amines
		Tyramine	Putrescine	Cadaverine	Histamine	
1	Control no amines added	4	14	17	0	35
2	Tyr, Put, Cad, Hist	92	111	180	5	388
3	Tyr, Put, Cad	94	109	183	0	386
4	Tyr, Put, Hist	95	116	18	5	234
5	Put, Cad, Hist	4	111	156	5	276
6*	Tyr, Cad,Hist	95	13	180	4	292

Table 2B. *Analyses of of biogenic amines in the experimental feeds analysed by IFREMER, Centre de Nantes in France:*

Trial feeds No	Biogenic amines added to feeds	mg amine free base/100 g feeds as is				Total biogenic amines
		Tyramine	Putrescine	Cadaverine	Histamine	
1	Control no amines added	trace	11	9	0	20
2	Tyr, Put, Cad, Hist	130	129	263	9	531
3	Tyr, Put, Cad	131	116	235	0	482
4	Tyr, Put, Hist	132	113	5	9	250
5	Put, Cad, Hist	trace	108	156	8	272
6	Tyr, Cad,Hist	143	10	261	9	423

Table 3 shows the initial and final weight and the specific growth rate of the salmon parr in the growth trial. There are no significant ($P>0.05$) differences in specific growth rate of the salmon parr fed the different experimental feeds. The specific growth rate was below what was expected. The reason is not known but it could be that the experiment was done in late autumn-early winter with natural photo period except during working hours when there was an electric working light. At this time of the year the day light time is short in Iceland.

Table 3. *The initial and final wet weight and specific growth rate of salmon parr fed for 79 days on the experimental feed.*

Trial feeds(as fed) No	Biogenic amine labelled feeds	Average weight at the beginning of trial	Average weight at the end of trial	Specific growth rate (%day)
1	Control no amines added	21.5	62.5	1.4
2	Tyr, Put, Cad, Hist	21.4	52.9	1.2
3	Tyr, Put, Cad	21.5	51.8	1.1
4	Tyr, Put, Hist	21.5	61.6	1.3
5	Put, Cad, Hist	21.7	57.1	1.2
6	Tyr, Cad,Hist	21.7	57.1	1.2

It can be seen from tables 4 and 5 that the feed intake differs a great deal between the two feeding methods (hand feeding and automatic feeding). One explanation might be that by automatic feeding all the feed falls in one spot making it easy for the more agressive fish to keep the less agressive fish away from the feed but during hand feeding however, the feed is distributed more evenly over the whole tank making it more available for all the fish. It counts of course that the hand fed fish was not fed between working hours which made them especially hungry during the intake quantification period in the morning compared to the fish fed by the continuous 24 hours feeding method. The different radiographic feed intake trials were done at different time of the day and the water temperature for the hand fed fish in the Guelph digestibility units was one degree higher than in the trial using automatic feeders. Both of these facts, might account for some of the feed intake difference between methods. Similarly there is also a difference between methods used to measure the intake (n-alkan indicator method and the radiography). In addition it has to be pointed out that the intake values measured by the different feeding methods and measurement techniques are not comparable as the duration of feeding is different. But still it seems apparent that the fish eat considerably more and therefore grows better when hand fed rather than fed by automatic feeder. This is seemingly even though the density and the disturbances for the hand fed fish in the Guelph units were greater than in the automatically fed growth trial. This is in an agreement with previous work by Thorpe et al., (1990) on Atlantic salmon, who found out that the consumption from an automatic feeder was at least 50% less than from hand-feedings.

There are no significant (P>0.05) differences in feed intake between the different experimental feeds shown in tables 4, 5 and 6, independent of methods or tanks used. Tables 4 and 5 also show the great variation in feed intake between individual fishes within the feed groups. The coefficient of variation is very high.

Table 4. *Feed intake measured by radiography in the 70 l tanks. (Guelph digestibility tanks). Feed is on dry matter basis.*

Feed groups	Trial feeds	Feed intake (mg on dry basis feed eaten per g wet weight fish) for 3 hours (9 am to 12 noon). Hand fed to satiation				Specific growth rate,%day (16 days)
Biogenic amines added	No	Average	Max	Min	CV* (%)	(% day)
Control no amines added	1	19.8	57.3	1.3	60.5	1.9
Tyr, Put, Cad, Hist	2	17.3	32.0	7.3	43.0	1.7
Tyr, Put, Cad	3	19.5	60.0	4.7	58.1	2.1
Tyr, Put, Hist	4	17.8	38.1	2.9	43.0	1.9
Put, Cad, Hist	5	15.7	31.5	8.1	38.5	1.9
Tyr, Cad,Hist	6	17.0	31.1	6.1	35.8	2.0

*Coefficient of variation between individual fishes

Table 5. *Labelled feed in the digestive tract of salmon parr measured by radiography, following a growth trial.*

Feed groups	Trial feeds	Feed intake (mg on dry basis feed eaten per g wet weight fish) for 10 hours (12 noon - 22:00 PM) continuous feeding with automatic disc feeder			
	No	Average	Max	Min	CV* %
Control no amines added	1	8.6	26.8	0.0	53.3
Tyr, Put, Cad, Hist	2	5.3	15.3	0.0	66.1
Tyr, Put, Cad	3	4.4	11.7	0.0	64.4
Tyr, Put, Hist	4	4.6	11.9	0.0	59.3
Put, Cad, Hist	5	6.5	16.1	0.0	56.3
Tyr, Cad,Hist	6	6.5	16.4	0.4	44.4

*Coefficient of variation between individual fishes

Table 6. *Feed intake in 70 l tanks (Guelph digestibility tanks) measured by n-alkanes indicator method.*

Feed groups	Trial feeds	Measured by n-alkanes indicator method
Biogenic amines added	No	Feed intake (mg on dry basis feed eaten per g wet weight fish)/(**per day**)
Control no amines added	1	11.3
Tyr, Put, Cad, Hist	2	9.0
Tyr, Put, Cad	3	14.0
Tyr, Put, Hist	4	11.2
Put, Cad, Hist	5	9.7
Tyr, Cad,Hist	6	15.6

Table 7. *Apparent digestibility and digestible energy of the different feeds*

		Apparent digestibility 100% dry matter				
Biogenic amines added to feeds	Trial feeds	Dry material	Protein	Fat	Ash	Digestible energy (dry matter)
	No	%				MJ/kg
Control no amines added	1	89.3	93.8	99.3	61.3	22.7
Tyr, Put, Cad, Hist	2	88.6	93.4	99.3	59.9	22.6
Tyr, Put, Cad	3	89.7	94.1	99.4	62.9	22.6
Tyr, Put, Hist	4	88.4	93.5	99.4	57.6	22.5
Put, Cad, Hist	5	89.9	94.2	99.4	62.9	22.7
Tyr, Cad,Hist	6	89.4	93.7	99.4	63.6	22.6

It can be seen in table 7 that little or no difference was found in the apparent digestibility of the dry matter, energy or nutrients due to biogenic amines in feeds, in fact no significant difference ($P>0.05$) was found. The digestibility was rather high, reflecting the high quality of the feed ingredients.

The results in these experiments are different from the results reported earlier on growth of salmon fry fed capelin meal based diets with high amounts of biogenic amines as free base (Tryggvadóttir et al., 1990, Tryggvadóttir et al., 1993). In these earlier works, reduced growth was found due to synthetic biogenic amines added to high quality capelin meal. Fry of 2-20 g were used, which could be much more sensitive than the parr used in this experiment with parr of 22-65 g. It can be added that the amount of histamine analysed in these experimental feeds fed to 2-20 g fry was only 7 mg/100 g. The earlier work by Tryggvadóttir et al., 1990, also show that when synthetic biogenic amines was added as hydrochlorids to the feeds, no growth reduction was found for 2-20 g fry. Biogenic amines as hydrochlorides do not have any putric smell as do biogenic amines as free base. It can be hypothesised that the small fry of 2 g are more sensitive to putric smell than parr of 22 g. However, the present experiments indicate that biogenic amines in high concentration, in otherwise good quality feeds, independent from other factors associated with poor quality, do not appear to reduce intake, digestibility or growth of salmon parr of this size.

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