THE USE OF DIETARY ACIDIFIERS IN SALMONID NUTRITION

with special focus on new results with diformates

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Data from the '90s of the last century obtained promising results in the use of dietary acidifiers in a number of salmonid species (Table 1).

The effect of supplementation of commercial diets with sodium salts of lactic and propionic acid was tested in Arctic charr (*Salvelinus alpinus*) in brackishwater at 8°C (Ringø 1991). Fish fed the diet with 1% added sodium lactate increased in weight from about 310 g to about 630 g in 84 days, while fish fed diets without either salts reached a final weight of only 520 g ($P<0.05$). Inclusion of 1% sodium propionate in the diet however had a growth depressing effect compared to the control ($P<0.05$). The gut content from Arctic charr fed the sodium lactate supplemented diet contained lower amounts of water, energy, lipid, protein and free amino acids.

Table 1: Effect of the sodium salt of different organic acids on the performance of Arctic charr and Atlantic salmon

Fish species	Acid/acid salt	Dose (%)	SGR (%)†	FCR††	Reference
Arctic charr	Control	0	0.61	n.d.	Ringø, 1991
	Na-lactate	1	0.83*		
	Na-propionate	1	0.49*		
Arctic charr	Control	0	0.51	1.20	Ringø, 1992
	Na-formate	1	0.58	1.08	
	Na-acetate	1	0.70*	0.96	
Arctic charr	Control	0	0.79	1.30	Ringø *et al.*, 1994
	Na-lactate	1	1.12	0.91	
Atlantic salmon	Control	0	0.97	n.d.	Gislason *et al.*, 1994
	Na-lactate	1.5	0.97		
Arctic charr	Control	0	0.28	n.d.	Gislason *et al.*, 1996
	Na-lactate	1.5	0.51*		
Atlantic salmon	Control	0	0.76	n.d.	Gislason *et al.*, 1996
	Na-lactate	1.5	0.79		

†SGR (%): Specific Growth Rate = ln Body $Mass_1$ – ln Body $Mass_0$ / Culture period (d) x 100

††FCR: Feed Conversion Ratio = Feed intake / Live weight gain

*significantly different from the control diet ($P<0.05$); n.d. – not determined

It has been observed that charr feeding on high doses of commercial feeds, as it often appears under aquaculture conditions, have a tendency for diarrhoea. When charr was feeding on diets containing sodium lactate, diarrhoea did not occur, probably indicating much lower amounts of remaining nutrients and water in the gut. Furthermore, it was proposed that the growth promoting effect of dietary lactate in Arctic charr is caused by the relatively slow gastric emptying rate (Gislason et al. 1996). An increased holding time in the stomach augments the antibacterial potential of the lactic acid salt and can have therefore a larger inhibition effect against possible pathogenic bacteria (Sissons 1989). The improved growth of the Arctic charr did not affect the chemical composition of the fish (Ringø et al. 1994).

A similar study by the same author (Ringø 1992) proved the growth promoting effect of 1% sodium acetate ($P<0.05$) given as an additive to Arctic charr reared in brackishwater, while the same dosage of sodium formate had only a numerical improvement compared to a negative control. The stimulated growth of the fish which fed the acetate additive may be explained to some extend by a higher feed intake, but the enhanced digestibilities of dietary components might also contribute to the increased growth. Addition of 1% sodium acetate to the diet affected significantly ($P<0.05$) the digestibility coefficients for both protein and lipid, and for the dietary fatty acids 14:0, 16:0, 18:1, 20:1, 22:1 including the essential fatty acids 18:0 and 18:2(n-6).

Further studies on salmonids included again the rainbow trout Oncorhynchus mykiss. The effect of organic acids on digestibility of minerals was tested in several studies. It was reported from pigs, that the inclusion of dietary organic acids enhances the mineral absorption (Ravindran and Kornegay 1993). Vielma and Lall (1997) reported the effect of die-

tary formic acid on the availability of phosphorous in such diets for rainbow trout. It was found that the apparent digestibility of phosphorous was significantly increased ($P<0.05$) in fish fed a diet containing 10 mL kg-1 formic acid.

"The use of acidifiers can be an efficient tool to achieve sustainable, economical, and safe fish production"

More recent studies include experiments with rainbow trout fingerlings (de Wet 2005, 2006), which were fed five experimental diets. Those diets consisted of a control diet, three diets containing 0.5, 1.0 and 1.5% of an organic acid blend (formic acid and its salts as well as sorbic acid) and a diet containing an AGP (40 ppm Flavomycin). At the end of the trial, improvement in growth was observed with increasing level of organic acid inclusion. Inclusion levels of 1.0% and 1.5% resulted in significant improvement in specific growth rate of the fish when compared to the control ($P<0.05$). The improvement was similar to what was achieved with AGP inclusion, if 1.5% of the acid blend were used. But fish fed the 1.5% acid blend tended to have a lower FCR compare to the group with in-feed antibiotics.

Latest results in salmonids reveal that Atlantic salmon fed 1.4% potassium diformate enriched fishmeal tended ($P=0.055$) to have a higher specific growth rate compared to a negative control (Christiansen and Lückstädt 2008). Furthermore, groups fed 0.8% and 1.4% potassium diformate fishmeal had a significantly better feed conversion and improved the uniformity of fish groups. This was confirmed by other data (Lückstädt, 2008; Lückstädt and Schulz, 2008; Lückstädt and Kühlmann, 2009)), where salmon fed on diets containing potassium diformate had significantly higher growth rates, an improved protein digestibility and a significantly higher fat digestibility respectively.

Further trials on the effect of diformate in salmon were recently published at the ISFNF in China (June 2010, see last issue of **Aquafeed - Advances in Processing and Formulation**). Especially the results from Morken et al. (2010) with sodium diformate on the physical quality of trout feed are of main interest for the fish feed industry. According to the authors sodium diformate at 1.06% can significantly improve hardness ($P<0.001$), water stability index ($P<0.001$) and durability ($P<0.001$) of extruded barley protein concentrate based fish feed, thus ensuring a safe feed uptake for the fish.

Though there are only a limited number of published studies on the use of acidifiers for growth promotion, feed efficiency as well as mineral absorption and pellet stability in salmonid aquaculture, results from those studies indicate promising potential and compel aquafeed manufacturers to consider using acidifiers, especially diformates in their diets. The use of acidifiers can be an efficient tool to achieve sustainable, economical, and safe fish production (Lückstädt, 2007).

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