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THE DIETARY EFFECTS OF POTASSIUM DIFORMATE ON THE PROTEIN AND FAT DIGESTIBILITY OF ATLANTIC SALMON (*SALMO SALAR*) REARED IN SEA WATER

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Introduction

Almost one-third of the world's fish harvest is not used for direct human consumption, but is converted into fish meal or fish oil for further application in animal feed. Therefore about 25 million tonnes of fish are handled annually and processed in ways other than fresh, frozen, smoked or canned (Balios, 2003). The supply of huge volumes of high quality fish meal is necessary to supply the rapid growing aquaculture industry, which is has been growing around 8.8% annually since the 1970's (FAO, 2007).

Acid preservation of fish and fish viscera to produce fish silage is common practice (Lückstädt, 2007) and the final product is widely used in fish feeds with beneficial effects reported (Gildbert and Raa, 1977; Åsgård and Austreng, 1981). Treatment with formic acid or potassium diformate is used to prolong fishing time or to extend the storage duration of caught fish. Previous studies using potassium diformate for fish meal preservation have resulted in improved nutrient digestibilities and growth performance in the nutrition of piglets or tropical fish species (Lückstädt, 2008). A recent study also showed the growth enhancing effects of potassium diformate treated fish meal on Atlantic salmon (Christiansen and Lückstädt, 2008).

However, data are still missing on the dietary nutrient digestibility of such treated fish meal. Therefore the effect of potassium diformate, added during fishmeal production, on nutrient digestibility in Atlantic salmon (*Salmo salar*) was investigated.

Materials and methods

The trial was conducted at AKVAFORSK's research station in Sunndalsøra, Norway. 560 Atlantic salmon, at an average weight of around 350 g, were allocated to tanks of 1 m^3 volume supplied with sea water (31-35‰) and a flow rate of 30dm^3 min^{-1}. 35 fish were placed in each tank at a mean temperature of 17 °C. The experimental fish were fed *ad libitum*, 24 hours a day one of 4 different test diets at 15 minute intervals. Three diets contained 1% potassium diformate (KDF), added at different stages of the feed production process (KDF-1: added to the raw fish (sand eel *Ammodytes marinus*); KDF-2: added during the drying process of the fish meal; KDF-3: added during the diet mixing), while the fourth diet served as a negative control. Each experimental diet was distributed between fish in four tanks. During the trial period of 96 days, fish faeces were stripped for determination of apparent digestibility of nutrients using yttrium oxide as an inert marker (Austreng, 1978).

Results

The growth was in accordance with growth tables developed for Atlantic salmon in sea water (Austreng *et al*., 1987), and there was no mortality during the trial period. There were no significant differences between dietary groups in the growth of fish during the trial period (SGR of 0.97, 0.97, 0.98 and 0.99 for KDF-1, KDF-2, KDF-3 and the negative control, respectively). Furthermore, there were no significant dietary differences in the digestibility of protein, starch,

dry matter or energy, while the diets containing potassium diformate had significantly higher fat digestibility compared to the control diet (Tab. 1). For protein, there was, however, a tendency to slightly higher digestibility in potassium diformate diets, compared to the control diet ($P = 0.12$ in contrast analysis).

Table 1. Digestibility of nutrients in Atlantic salmon fed diets with or without potassium diformate KDF

Diet	Protein (%)	Fat (%)	Starch (%)	Dry matter (%)	Energy (MJ kg^{-1})
KDF-1	87.2	95.1[a]	49.3	73.0	84.7
KDF-2	87.2	94.3[a]	53.9	72.2	83.5
KDF-3	87.3	94.6[a]	52.1	75.5	84.1
Control	86.9	93.3[b]	57.8	72.7	83.6
P-value	0.434	0.001	0.091	0.315	0.060

[a, b]within columns: means with a different superscript are significantly different ($P < 0.05$)

Discussion

The positive effects of potassium diformate on the growth of Atlantic salmon, as reported by Christiansen and Lückstädt (2008) were not confirmed in the present study. However, there was a clear tendency to improved protein digestibility, as is often reported after the inclusion of an organic acid salt into the diets of animals (Metzler and Mosenthin, 2007). Furthermore, lipid digestibility in salmon could be significantly improved by KDF addition. Antimicrobial effects of KDF could indirectly influence lipid absorption processes in salmon. In addition, molecular constituents of KDF contribute to systemic acid-base homeostasis and cellular transport mechanisms, with possible interactions with lipid metabolism (Miller, 1995).

As our knowledge about KDF application on dietary nutrient digestibility in aquaculture is scarce, further investigation is needed to clearly identify its role in fish metabolism.

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