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Short note/Kurze Mitteilung

Utilization of acidifiers in nutrition and feeding of tropical fish – a mini-review*

Einsatz von organischen Säuren in der Ernährung tropischer Fische – ein kurzer Überblick

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Zusammenfassung: Die Verwendung von Fischsilagen ist bereits seit Jahrzehnten in der Praxis weit verbreitet. Fischsilagen sind Fischabfälle, die durch den Einsatz von organischen Säuren haltbar gemacht und teilweise an Fische verfüttert werden. Daher wurde die Idee eines direkten Einsatzes von Säureadsorbaten im Fischfutter von mehreren Forschungsinstituten aufgegriffen. Unter einem Säureadsorbat versteht man organische Säuren oder deren Salze, die auf einen anorganischen Träger aufgebracht wurden. Untersucht wurde der Einfluss von Säureadsorbaten im Futter auf das Wachstum verschiedener tropischer Fischarten, unter anderem bei Tilapia (*Oreochromis niloticus*), afrikanischen Welsen (*Clarias gariepinus*), Seebrassen (*Pagrus major*) und bei Indischen Karpfen (*Labeo rohita*). Es wurde dabei festgestellt, dass durch den Einsatz dieser Additive im Futter der Fische das Wachstum gesteigert, sowie die Futterverwertung als auch die Verdaulichkeit diverser Minerale verbessert werden konnte.

Routine use of antibiotics as growth promoters is a matter of debate in the animal farming industry. The use of low levels of these antibiotics in animal feeds possesses the possibility to transfer bacterial immunity to species pathogenic in animals and humans (Liem 2004). The EU banned all antibiotic growth promoters (AGP) from livestock production with effect of January 2006. Public opinion and regulatory authorities in most exporting countries now focus on the misuse of antibiotics in aquaculture and attention has shifted towards production methods. The worldwide search for alternatives to AGP has resulted in a variety of different strategies. Acidifiers consisting of organic acids and their salts present a promising alternative and they have received much attention as a potential replacement for AGP in order to improve the performance and the health of treated animals. In animal nutrition, acidifiers exert their effects on performance via three different ways (Freitag 2007): (a) in the feed; (b) in the gastro-intestinal tract of the animal; and (c) due to effects on the animal's metabolism.

In aquaculture, the use of acidifiers has a long history. Acid preservation of fish and fish viscera to produce fish silage is common practice and is widely used in fish feeds with reported beneficial effects (Gildbert & Raa 1977, Åsgård & Austreng 1981). According to Batista (1987) the fish silage production was initiated in the 1930's, using sulphuric and hydrochloric acids to preserve fish waste.

The beneficial effects of acid-preserved products attracted attention from the scientific community and the effects of adding these short-chain acids directly onto the fish feed have been investigated. Several studies have been conducted with different tropical species including herbivorous filter feeders (tilapia) and omnivorous fish (sea bream, carp, catfish).

Ramli et al. (2005) tested potassium diformate (the potassium salt of formic acid) as a growth

*Presented at the "6th Tagung der Gesellschaft für Ichthyologie (GfI)" at the "Zoologische Staatssammlungen" in Munich from 13-15 March 2008 promoter in tilapia grow-out in Indonesia (tab. 1). In this study, fish were fed over a period of 85 days six times a day, on diets containing different concentrations of potassium diformate (0%, 0.2%, 0.3% and 0.5%). The diets contained 32% crude protein, 25% carbohydrates, 6% lipids and 10% fibre. The fish were challenged orally starting day 10 of the culture period with *Vibrio anguillarum* at 10^5 CFU per day over a period of 20 days.

Over the entire feeding period from day 1 to 85, potassium diformate significantly increased feed intake ($P<0.01$) and weight gain ($P<0.01$) and improved furthermore the feed conversion ratio significantly ($P<0.01$). Survival rates of fish after the challenge with *V. anguillarum* on day 10 were also significantly higher compared to the negative control and the effect was dose dependent ($P<0.01$).

The authors concluded that the application of potassium diformate at 0.2% is an efficient tool to control bacterial infections in tropical tilapia culture.

Similar results were achieved by ZHOU et al. (2008), who tested hybrid tilapia (*Oreochromis niloticus* x *Oreochromis aureus*) fingerlings (2.7 g initial weight) in a dose response study with potassium diformate (0%, 0.3%, 0.6%, 0.9% and 1.2%), while also comparing the results with an antibiotic growth promoter (8 mg/kg Flavomycin). During the 56 day trial period, tilapia fed all the potassium diformate enriched diets grew faster than the negative control (an increase of up to 11.6%), while fish fed 0.3% and 0.6% potassium diformate achieved even better weight gain than the fish in the positive control group. The authors speculated that dietary potassium diformate could stimulate a beneficial bacterial colonization of the intestine.

Another study in tilapia (*Oreochromis niloticus*) looked at the stimulation of feeding behaviour with different organic acids (XIE et al. 2003), as is sometimes reported with different organic acids or their salts in pigs (PAULICKS et al. 1996). The result showed that citric acid at a concentration of 10^{-2} to 10^{-6} M and lactic acid at 10^{-2} to 10^{-5} M stimulated feeding, as automatically recorded via the frequency of feeding "bites". On the other hand, fish tended to avoid acetic acid at 10^{-3} M. The inclusion of acetic acid at 10^{-5} M had no significant effects on feeding.

A more recent trial (PETKAM et al. 2008) determined the effects of an acid blend, containing calcium formate, calcium propionate, calcium lactate, calcium phosphate and citric acid at different levels (0.5%, 1.0% and 1.5%) on the growth performance of tilapia (*Oreochromis niloticus*). Fish were fed to satiation two times a day during an eight week period, using a pelletized diet containing 31% crude protein.

Tab. 1: Effects of potassium diformate supplementation in diets on performance of tilapia challenged with *V. anguillarum* (modified from RAMLI et al. 2005).

Tab. 1: Effekte der Supplementierung mit Kaliumdiformiat auf Wachstumsparameter von Tilapien, die oral mit *V. anguillarum* infiziert wurden (nach RAMLI et al. 2005).

	Potassium diformate inclusion in diet (%)			
	0	**0.2**	**0.3**	**0.5**
Initial weight (g)	16.7	16.7	16.7	16.7
Final weight (g)	218^a	258^c	246^b	252^{bc}
FCR	1.34^a	1.23^b	1.25^b	1.22^b
Mortality (%), day 10-85	33.0^a	20.8^b	18.4^b	11.0^c

^{abc}within rows, means without common superscripts are significantly different ($p<0.05$)

Tab. 2: Performance data (Mean ± SD) of tilapia fed three different test diets (modified from PETKAM et al. 2008).
Tab. 2: Wachstumsparameter (Mittelwert ± SD) von mit drei Testdiäten gefütterten Tilapien (nach PETKAM et al. 2008).

Treatment	Final length (in cm)	Final weight (in g)	FCR
Negative control	12.49 ± 0.12	37.91 ± 1.53	1.43 ± 0.06
Positive control (AGP)	12.75 ± 0.12	40.25 ± 0.55	1.40 ± 0.00
Acidifier treatment (1.5%)	12.92 ± 0.50	41.33 ± 2.92	1.38 ± 0.09

Despite a lack of statistically significant data on growth and FCR, the inclusion of the acidifier at 1.5% of the diet resulted in a numerical (11%) increase in body weight when compared to the negative control and achieved similar results to the AGP-supplemented diet (0.5% Oxytetracycline) (tab. 2).

Organic acid salts may be especially valuable during the grow-out period in tilapia culture (LÜCKSTÄDT 2008).

Further research was devoted to sea bream, *Pagrus major*, in order to determine the phosphorous utilization after feeding dietary organic acids, as seen in previous studies with different fish species (HOSSAIN et al. 2007). The use of 1% citric acid, 1% malic acid and 1% lactic acid in 3 different dietary groups led to significantly better weight gain and feed conversion ratio in the citric acid supplemented group, compared to the negative control. The use of neither malic nor lactic acid improved the performance of sea bream. The phosphorous excretion in the citric acid fed bream, as well as in the malic acid and lactic acid fed groups was also significantly reduced, suggesting a better utilization of this mineral in the fish. The higher absorption of phosphorous in the diet with supplemented organic acid is in agreement with other reports that citric acid might increase the apparent digestibility of many minerals including phosphorous in fishmeal (SUGUIRA et al. 1998a, SARKER et al. 2005).

Despite the lack of success in agastric goldfish in Europe (SUGUIRA ET AL. 1998b), acidifiers have also been tested in agastric Indian carp (*Labeo rohita*). A study carried out by BARUAH et al. (2005) determined the interactions of dietary protein level, microbial phytase and citric acid on bone mineralization of *Labeo* juveniles. Data showed that the addition of 3% citric acid to either a low (25%) or high protein diet (35%) resulted in significantly decreased pH in feed and intestinal digesta. Furthermore, bone ash content was significantly increased, suggesting a better bioavailability of minerals. Bone minerals are in close agreement with these finding, since, for example, phosphorous retention in the skeleton after citric acid supplementation was also significantly increased. DEBNATH et al. (2005) suggest synergistic effects between microbial phytase and organic acids in this respect. A follow up study (BARUAH et al. 2007a) investigated the synergistic effect of citric acid and phytase on nutrient digestibility and growth performance in Indian carp, again in low and high protein diets. Addition of citric acid in both diets significantly increased the weight gain (WG) and SGR of carp juveniles, while it reduced the FCR. No effects where observed on protein efficiency ratio (PER) or apparent net protein utilization (ANPU). However, a significant interaction between citric acid and microbial phytase (at 500 U kg^{-1}) was found on WG, SGR, PER and ANPU, further supporting the findings of DEBNATH et al. (2005). Finally, BARUAH et al. (2007b) found that citric acid and microbial phytase have a synergistic effect on mineral bioavailability, as measured in the whole body and the plasma, and this effect was more prominent in low protein diets.

Other omnivorous fish species have also been supplemented with acidifiers. In a recent trial, OWEN et al. (2006) tested the sodium salt of butyric acid as a feed additive in the tropical catfish, *Clarias gariepinus*, at 0.2% in two diets: the main protein source in one diet was fishmeal and in the other diet was defatted soya. Slightly higher growth and concomitant reduction in FCR were observed in catfish fed the fishmeal diet supplemented with sodium butyrate when compared with the control diet, while fish receiving defatted soya together with 0.2% Na-butyrate did not show any improvement at all. The SGR increase in the fishmeal fed butyrate group was more than 4%, while the improvement in feed efficiency was also about 4%. However, both indices differed non-significantly from the control. Sodium butyrate supplementation did appear to increase the proportion of gram positive bacteria in the hindgut of *C. gariepinus*, though this increase was not statistically significant.

Despite the limited number of published studies on the use of acidifiers for growth promotion, feed efficiency, mineral absorption and disease prevention in tropical finfish aquaculture, results from such studies indicate promising potential and compel aqua feed manufacturers to consider using acidifiers 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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