fishes

Effects of Dietary Sodium Butyrate on Growth Performance, Digestive Ability, Blood Biochemistry, and Ammonia Tolerance of Largemouth Bass (Micropterus salmoides)

MDPI

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Introduction

Short-chain fatty acids (SCFAs) are metabolic products of the intestinal microbiota and can participate in the body's metabolism, being crucial for the growth, intestinal function, and immunity of aquatic animals. Sodium butyrate, as one type of SCFAs, can improve the intestinal function and antioxidant capacity of fish, and enhance growth performance. In recent years, under high-density aquaculture, ammonia stress has caused harm to fish, resulting in inhibited growth and increased mortality rates. Adding sodium butyrate to feed can alleviate ammonia toxicity in yellow catfish, but the effect varies among fish. The largemouth bass was introduced to China in 1983 and had a production of 802,486 tons in 2022. High-density aquaculture has made ammonia stress a problem, with water ammonia concentrations exceeding the tolerance threshold. This experiment evaluated the effects of adding sodium butyrate to feed on the growth and digestion of the fish.

Methods

Experimental design

Three groups of feed formulations were prepared (0.0%, 0.5%, and 1.0% SB).

Animal grouping: 9 tanks (30 fish per tank, 3 replicates per group)

Standardized breeding: Water temperature 28 ± 0.2℃, dissolved oxygen > 7.0mg/l, pH 6.5 - 7.0. Feed twice daily (at 8:00/18:00), record feed consumption, and change water 1/3 every day.

Sample collection: Routine sampling (after fasting for 24 hours, MS-222 (120 mg/L) anesthetized sampling)

Indicator testing: Body composition; Serum biochemistry; Enzyme activity; Omics analysis; Gene expression

Results

1.Dietary SB Supplementation on Growth

	SB Levels (%) 0.00	0.50	1.00
FBW (g)	34.73 ± 0.37 ^{a}	39.47 ± 0.69 ^{b}	39.01 ± 0.36 ^{b}
WGR (%)	369.32 ± 5.05 ^{a}	433.38 ± 9.26 ^{b}	427.12 ± 4.85 ^{b}
SGR (%/d)	2.76 ± 0.02 ^{a}	2.99 ± 0.03 ^{b}	2.96 ± 0.02 ^{b}
FCR	1.47 ± 0.04	1.46 ± 0.02	1.47 ± 0.02
FI (g/fish)	37.88 ± 0.23 ^{a}	47.94 ± 0.83 ^{b}	47.70 ± 0.79 ^{b}
CF (g/cm^3)	1.57 ± 0.02 ^{a}	1.75 ± 0.04 ^{b}	1.67 ± 0.06 ^{b}
HSI (%)	1.74 ± 0.02	1.77 ± 0.05	1.75 ± 0.02
SR (%)	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00

Table 1. Effects of different dietary levels of SB on growth performance of large-mouth bass.

	SB Levels (%) 0.00	0.50	1.00
Protein (% dry matter)	57.70 ± 0.28 ^{a}	59.68 ± 0.42 ^{b}	58.98 ± 0.45 ^{b}
Lipid (% dry matter)	27.13 ± 0.63	27.49 ± 0.37	27.75 ± 0.24
Ash (% dry matter)	11.22 ± 0.44 ^{a}	12.48 ± 0.20 ^{b}	11.97 ± 0.28 ^{b}
Moisture (%)	69.83 ± 0.57	69.71 ± 0.40	69.40 ± 0.26

Table 2. Effects of different dietary levels of SB on whole body proximate components of large-mouth bass.

Table 3. Effects of different dietary levels of SB on digestive enzyme activities of large-mouth bass

	SB Levels (%) 0.00	0.50	1.00
Liver			
Pepsin (U/mg prot)	6.69 ± 0.29 ^{a}	9.02 ± 0.53 ^{b}	8.80 ± 0.50 ^{b}
Lipase (U/g prot)	3.78 ± 0.05 ^{a}	3.95 ± 0.01 ^{b}	3.91 ± 0.03 ^{b}
Amylase (U/mg prot)	0.48 ± 0.02	0.46 ± 0.043	0.44 ± 0.04

	SB Levels (%) 0.00	0.50	1.00
Intestine			
Pepsin (U/mg prot)	0.75 ± 0.06 ^{a}	0.93 ± 0.05 ^{b}	0.91 ± 0.01 ^{b}
Lipase (U/g prot)	1.20 ± 0.01 ^{a}	1.46 ± 0.05 ^{b}	1.47 ± 0.04 ^{b}
Amylase (U/mg prot)	0.21 ± 0.01 ^{a}	0.24 ± 0.01 ^{b}	0.24 ± 0.03 ^{b}
Intestinal content			
Pepsin (U/mg prot)	6.68 ± 0.45 ^{a}	8.68 ± 0.36 ^{b}	8.92 ± 0.65 ^{b}
Lipase (U/g prot)	2.98 ± 0.05 ^{a}	3.12 ± 0.04 ^{b}	3.19 ± 0.01 ^{b}
Amylase (U/mg prot)	0.71 ± 0.01 ^{a}	0.81 ± 0.01 ^{b}	0.79 ± 0.03 ^{b}

2.Dietary SB Supplementation on Health

	SB Levels (%) 0.00	0.50	1.00
AKP (U/mg prot)	37.12 ± 0.33 ^{a}	46.06 ± 0.70 ^{c}	45.44 ± 0.80 ^{b}
Na^+/K^+-ATPase (U/mg prot)	3.83 ± 0.37 ^{a}	6.86 ± 0.44 ^{c}	4.06 ± 0.35 ^{b}
GGT (U/mg prot)	8.75 ± 0.05 ^{a}	11.12 ± 0.09 ^{c}	10.01 ± 0.11 ^{b}
CK (U/mg prot)	19.88 ± 0.06 ^{a}	25.33 ± 0.15 ^{c}	21.12 ± 0.11 ^{b}

Table 4. Effects of different dietary levels of SB on intestinal brush border membrane enzyme activity of large-mouth bass.

	SB Levels (%) 0.00	0.50	1.00
TP (g/L)	33.63 ± 1.13 ^{a}	36.80 ± 1.30 ^{b}	36.83 ± 0.68 ^{b}
ALB (g/L)	11.53 ± 0.38 ^{a}	12.25 ± 0.15 ^{b}	12.65 ± 0.15 ^{b}
GLO (g/L)	21.04 ± 0.44 ^{a}	23.28 ± 0.74 ^{b}	23.05 ± 0.75 ^{b}
TG (mmol/L)	10.98 ± 0.52 ^{b}	8.60 ± 0.37 ^{a}	8.50 ± 0.08 ^{a}
CHOL (mmol/L)	0.13 ± 0.03 ^{b}	0.05 ± 0.01 ^{a}	0.06 ± 0.01 ^{a}
ALT (U/L)	2.33 ± 0.58	2.25 ± 0.25	2.50 ± 0.50
AST (U/L)	77.63 ± 4.13 ^{b}	62.88 ± 4.88 ^{a}	64.33 ± 2.31 ^{a}

Table 5. Effects of dietary SB supplemented with different levels for 56 days on serum biochemistry oflarge-mouth bass.

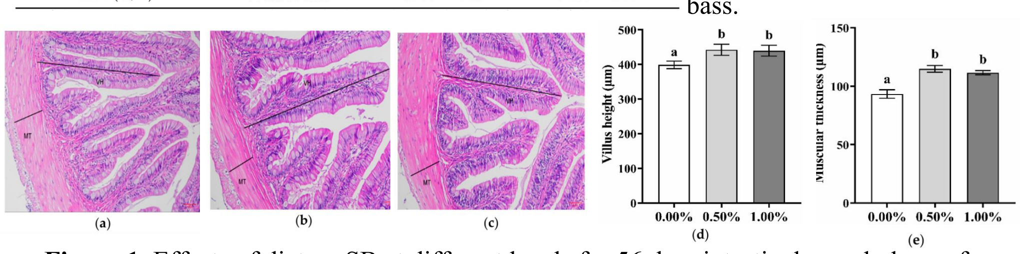

Figure 1. Effects of dietary SB at different levels for 56 d on intestinal morphology of largemouth bass.(a) 0.00% SB; (b) 0.50% SB; (c) 1.00% SB; (d) villus height (VH); (e) muscular thickness (MT).

Results

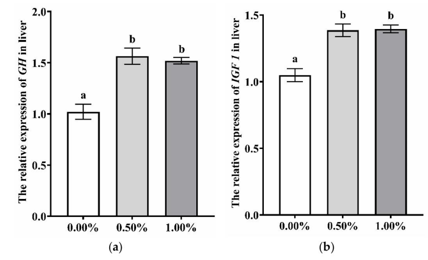

Figure 2. Relative expression levels of growth-related genes GH (a) and IGF 1 (b) in the liver of largemouth bass after 56 days of culture.

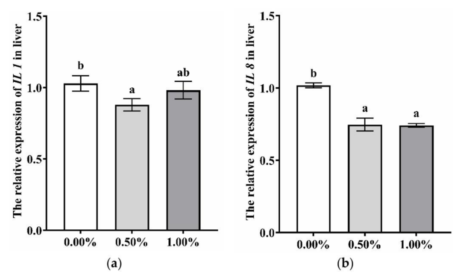

Figure 3. Relative expression levels of inflammation-related genes IL 1 (a) and IL 8 (b) in the liver of largemouth bass after 56 days of culture.

3. Dietary SB Supplementation on Ammonia Tolerance

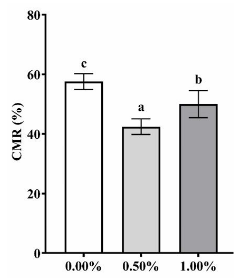

Figure 4. Effect of SB on cumulative mortality rate (CMR) of large-mouth bass under 96 h of ammonia stress.

	SB Levels (%) 0.00	0.50	1.00
ASS (U/g prot)	9.33 ± 0.09 ^{a}	11.12 ± 0.05 ^{b}	11.08 ± 1.01 ^{b}
ASL (U/g prot)	15.35 ± 1.01 ^{a}	17.66 ± 0.05 ^{b}	17.35 ± 0.07 ^{b}
ARG (U/g prot)	6.58 ± 0.01 ^{a}	7.15 ± 0.26 ^{b}	7.09 ± 0.05 ^{b}

	SB Levels (%) 0.00	0.50	1.00
OTC (U/g prot)	15.35 ± 0.15 ^{a}	16.47 ± 0.09 ^{b}	16.89 ± 0.12 ^{b}
nNOS (U/g prot)	0.43 ± 0.04 ^{b}	0.35 ± 0.01 ^{a}	0.31 ± 0.03 ^{a}
iNOS (U/g prot)	0.66 ± 0.01 ^{a}	1.12 ± 0.01 ^{b}	1.15 ± 0.05 ^{b}

Table 6. Effects of 96 h of ammonia exposure on the activities of ammonia metabolism enzymes and nitric oxide synthase in the liver of large-mouth bass.

Conclusions

This study showed that dietary supplementation with SB can improve the growth performance of largemouth bass by increasing the FI, promote growth by increasing the activity of digestive enzymes and improving the intestinal morphology, improve blood health by increasing the content of TP, ALB and GLO, and by decreasing the content of TG, CHOL, and AST, and increase the activity of ammonia metabolism enzymes and iNOS, decrease nNOS, and enhance the capacity of urea cycle, thereby increasing ammonia tolerance. The determination of the optimal addition amount of SB in the diet is an important study that urgently needs to be carried out.

References

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