读书报告

唐文彧

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文章题目

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Dietary *Lycium barbarum* extract administration improved growth, meat quality and lipid metabolism in hybrid grouper (*Epinephelus lanceolatus* ♂ × *E. fuscoguttatus* ♀) fed high lipid diets

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目 录/contents

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第一章

前言

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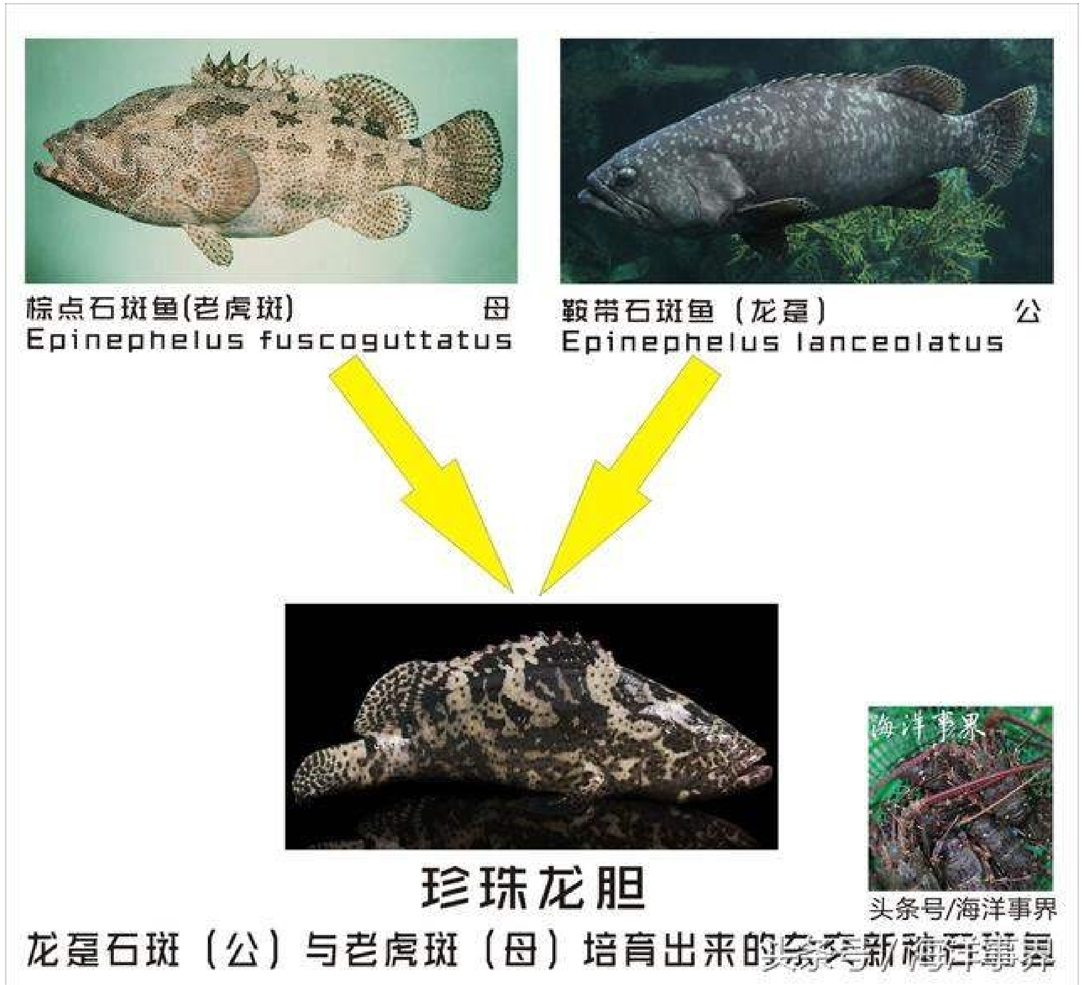
前　言



- 杂交石斑鱼因其生长速度快、营养价值高、抗病性强等特点，在我国东南沿海得到了广泛的养殖。

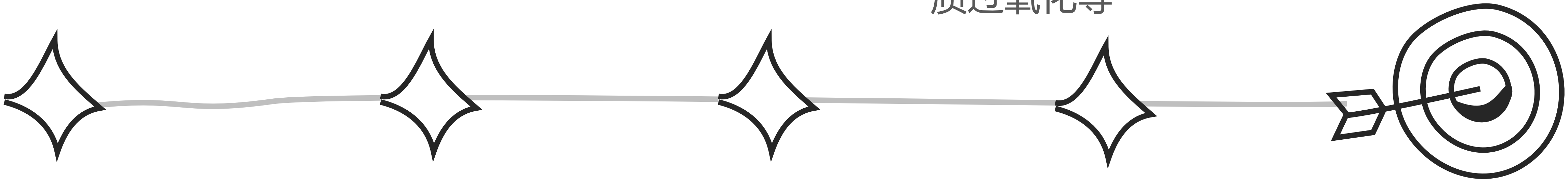
前　言

目前对杂交石斑鱼营养的研究非常有限，仅涉及膳食蛋白和脂质需求。

饲料蛋白质含量较高，增加了杂交石斑鱼养殖的成本。

脂肪具有蛋白质节约效应，高脂日粮作为一种能源被广泛应用于经济水产养殖中，以节约日粮蛋白，降低养殖成本。

高脂饮食会对养殖鱼产生一系列负面影响，如生长缓慢、免疫抑制炎症、脂肪肝和脂质过氧化等



前　言

- 枸杞作为著名的中药和功能食品已经被广泛使用。
- 现代药理研究发现，枸杞多糖是枸杞的主要活性成分。前人研究表明，枸杞具有增强免疫和抗氧化能力、抗应激、保肝作用、降血糖和降血脂作用。

- 在小鼠中，高脂肪饮食中添加枸杞多糖能改善血脂代谢和抗氧化能力。
- 这些结果表明，枸杞提取物作为高脂饮食的补充，在改善鱼体生长性能和免疫能力，抑制脂质积累方面具有很大的潜力。

第二章

材 料 与 方 法

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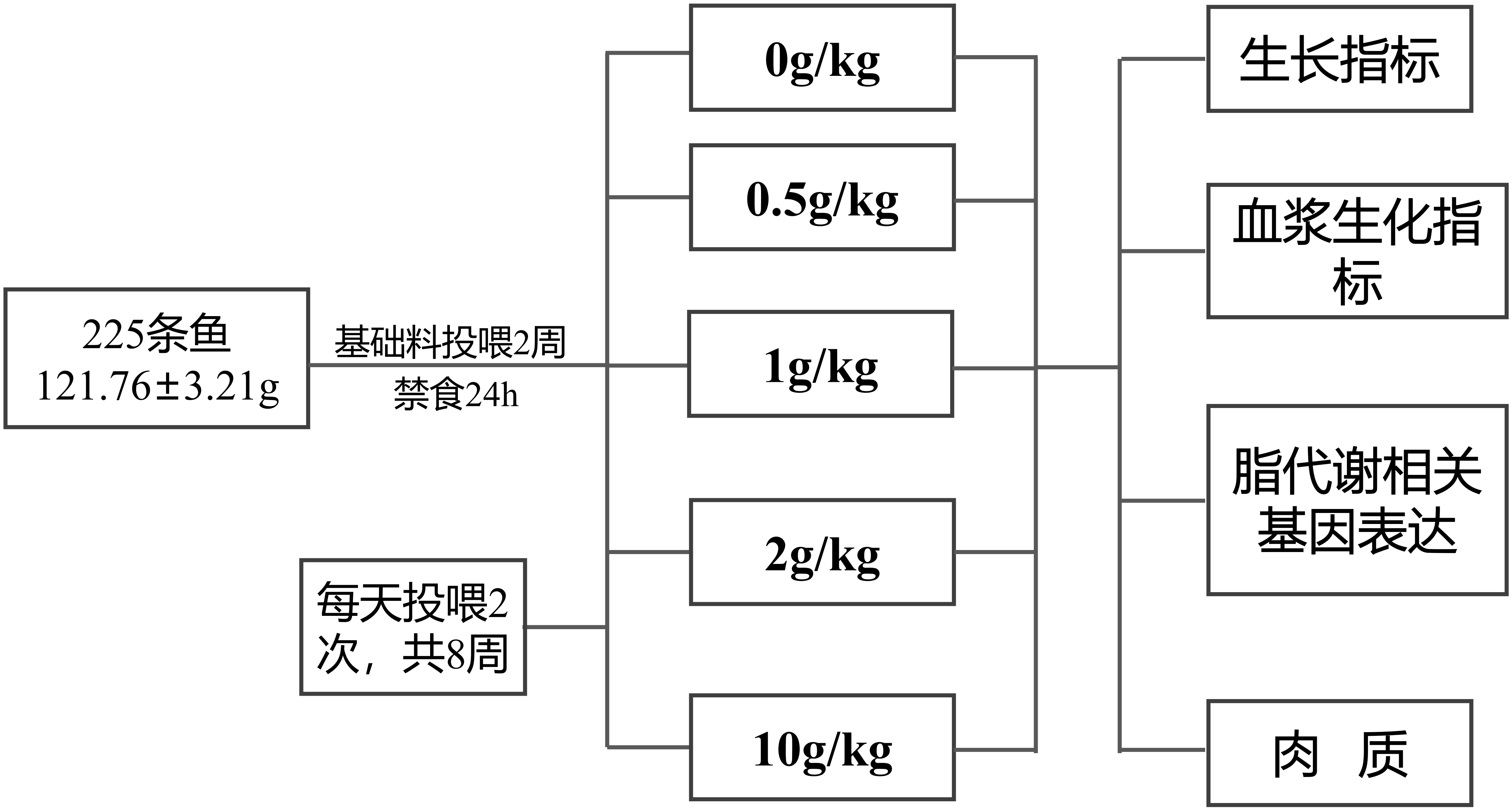
材料与方法



225条鱼
121.76±3.21g
基础料投喂2周
禁食24h
每天投喂2次，共8周
0g/kg
0.5g/kg
1g/kg
2g/kg
10g/kg
生长指标
血浆生化指标
脂代谢相关基因表达
肉 质

材料与方法

Table 1
Composition and nutrient levels of experimental diets (g kg^{-1}).

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish meal	450.0	450.0	450.0	450.0	450.0
Soybean meal	130.0	130.0	130.0	130.0	130.0
Flour	237.4	237.4	237.4	237.4	237.4
Beer yeast powder	50.0	50.0	50.0	50.0	50.0
Fish oil	50.0	50.0	50.0	50.0	50.0
Soybean oil	50.0	50.0	50.0	50.0	50.0
Lecithin	10.0	10.0	10.0	10.0	10.0
Vitamin premix[a]	2.0	2.0	2.0	2.0	2.0
Mineral premix[b]	5.0	5.0	5.0	5.0	5.0
Choline chloride (50%)	5.0	5.0	5.0	5.0	5.0
Antioxidant	0.1	0.1	0.1	0.1	0.1
Vitamin C	0.5	0.5	0.5	0.5	0.5
Monocalcium phosphate	10.0	10.0	10.0	10.0	10.0
Lycium barbarum extract[c]	0	0.5	1.0	2.0	10.0
Nutrient levels (%)					
Moisture	5.12	5.73	5.61	5.65	5.10
Crude protein	46.63	46.78	46.58	46.24	46.23
Crude lipid	14.81	14.67	14.72	14.72	14.73
Ash	10.36	10.31	10.33	10.40	10.42

第三章

结 果

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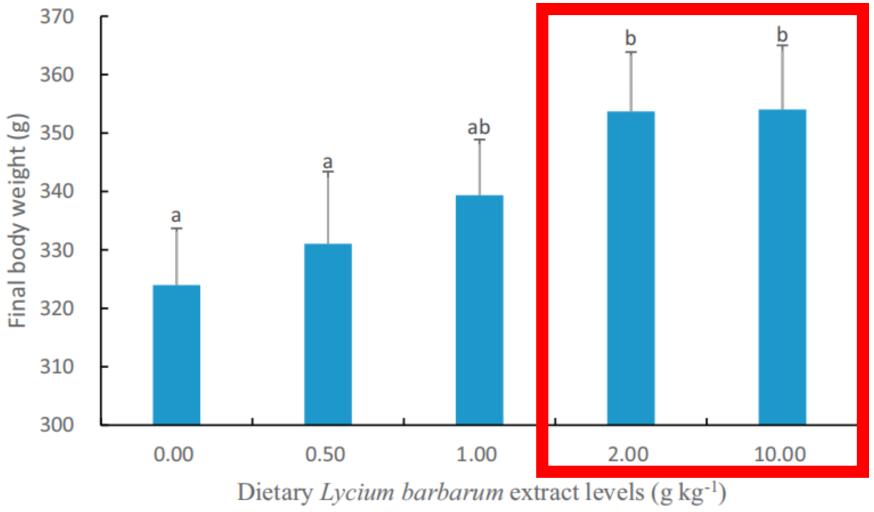
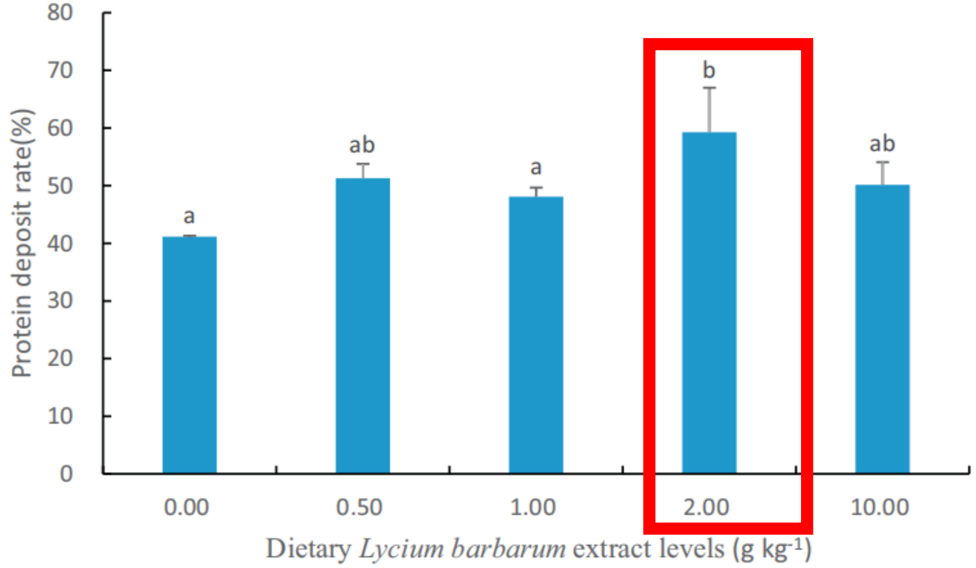
结　　果

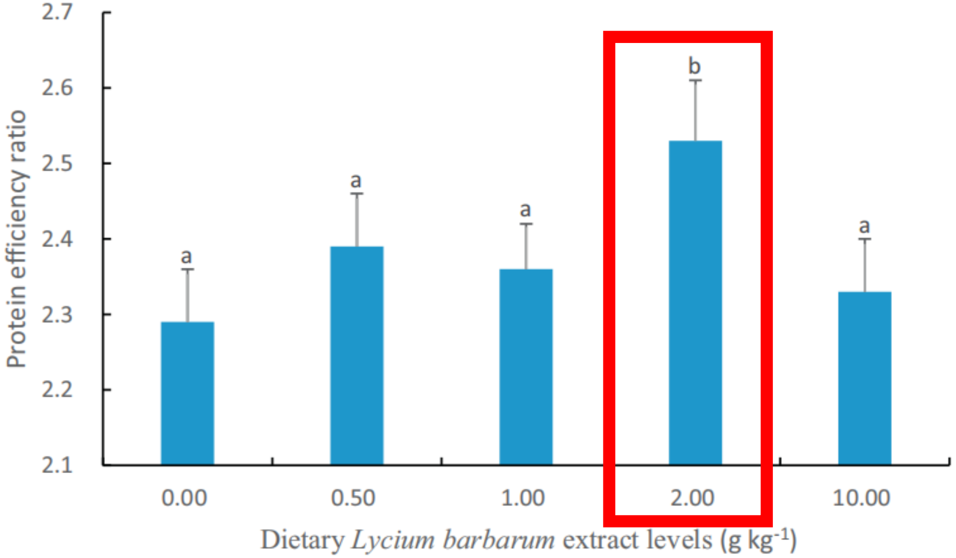
X. Tan et al.



终体重



蛋白沉积比



蛋白效率比

结　　果

Table 3

Effects of dietary *Lycium barbarum* extract levels on body morphologic indices in hybrid grouper.

Diets (g kg^{-1})	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	ANOVA (*P*)	Linear trend (*P*)	Quadratic trend (*P*)	
	0	0.50	1.00	2.00	10.00				
CF (g/cm^3)	2.56 ± 0.18^{ab}	2.54 ± 0.11^{a}	2.68 ± 0.19^{bc}	2.72 ± 0.13^{c}		2.65 ± 0.10^{abc}	0.017	0.026	0.058
VSI (%)	7.94 ± 0.68^{a}	8.65 ± 0.87^{ab}	9.25 ± 1.05^{b}	9.39 ± 1.01^{b}		8.95 ± 0.53^{ab}	0.076	0.065	0.023
HSI (%)	1.56 ± 0.40^{a}	1.69 ± 0.42^{a}	1.97 ± 0.36^{ab}	2.23 ± 0.15^{b}		1.83 ± 0.47^{ab}	0.047	0.092	0.018
SI (%)	0.13 ± 0.02^{a}	0.22 ± 0.04^{b}	0.20 ± 0.02^{b}	0.23 ± 0.08^{b}		0.21 ± 0.06^{b}	0.049	0.056	0.052
AFP (%)	2.57 ± 0.25	2.22 ± 0.35	2.17 ± 0.28	2.15 ± 0.26		2.43 ± 0.37	0.229	0.945	0.025
RGL (%)	133.89 ± 9.54	134.61 ± 14.98	143.68 ± 17.75	135.88 ± 9.67		137.65 ± 3.40	0.711	–	–

Values are means ± SD of three replications. Means in the same raw with different superscripts are significantly different ($P < .05$).

CF: condition factor; VSI: viscerosomatic index; HSI: hepatosomatic index; SI: spleen index; AFP: abdominal fat percentage; RGL: relative gut length.

结 果

Table 4
Effects of dietary *Lycium barbarum* levels on plasma biochemical indices of hybrid grouper.

Diets (g kg^{-1})	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	ANOVA (*P*)	Linear trend (*P*)	Quadratic trend (*P*)
	0	0.50	1.00	2.00	10.00			
CHO/(mmol L^{-1})	3.31 ± 0.64^{b}	2.71 ± 0.13^{ab}	2.62 ± 0.29^{ab}	2.31 ± 0.16^{a}	2.51 ± 0.34^{ab}	0.172	–	–
TG/(mmol L^{-1})	2.75 ± 0.72	2.16 ± 0.18	2.17 ± 0.41	2.21 ± 0.40	2.63 ± 0.38	0.595	–	–
GLU/(mmol L^{-1})	4.37 ± 0.14^{b}	2.46 ± 0.16^{a}	2.48 ± 1.07^{a}	1.69 ± 0.29^{a}	1.34 ± 0.11^{a}	0.012	0.002	0.06
TP/(g L^{-1})	48.85 ± 0.35^{a}	50.55 ± 0.64^{ab}	53.25 ± 1.77^{b}	52.60 ± 0.71^{ab}	49.35 ± 2.76^{ab}		–	–
ALP/(U L^{-1})	100.50 ± 0.71^{a}	110.00 ± 1.41^{ab}	116.00 ± 1.41^{b}	114.00 ± 9.90^{b}	101.50 ± 0.71^{a}	0.535	–	–
LDL/(mmol L^{-1})	0.35 ± 0.02^{b}	0.30 ± 0.02^{ab}	0.28 ± 0.04^{a}	0.28 ± 0.03^{a}	0.27 ± 0.01^{a}	0.151	–	–
HDL/(mmol L^{-1})	0.10 ± 0.01^{a}	0.12 ± 0.00^{b}	0.13 ± 0.01^{b}	0.12 ± 0.02^{ab}	0.13 ± 0.01^{b}	0.119	0.03	0.152

结　果

Table 5
Effects of dietary *Lycium barbarum* levels on whole body, muscle and liver proximate composition of hybrid grouper.

Diets ($g\ kg^{-1}$)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	ANOVA (*P*)	Linear trend (*P*)	Quadratic trend (*P*)
	0	0.50	1.00	2.00	10.00			
Whole body								
Moisture	66.44 ± 0.30[c]	62.61 ± 1.21[ab]	64.57 ± 1.74[bc]	62.62 ± 1.77[ab]	60.78 ± 2.11[a]	0.059	0.018	0.701
Crude protein	49.39 ± 2.05[a]	52.67 ± 0.96[b]	55.81 ± 1.29[c]	52.29 ± 0.63[ab]	50.53 ± 0.03[ab]	0.009	0.427	0.002
Crude lipid	24.81 ± 0.50[c]	23.01 ± 0.59[b]	21.17 ± 1.02[a]	21.57 ± 0.38[ab]	22.18 ± 0.38[ab]	0.011	0.009	0.005
Ash	13.97 ± 1.30	13.27 ± 0.83	13.32 ± 1.47	13.03 ± 0.90	12.70 ± 1.86	0.889	–	–
Muscle								
Moisture	72.28 ± 2.50[a]	73.72 ± 0.04[a]	74.60 ± 0.70[a]	74.21 ± 1.09[a]	73.91 ± 0.05[a]	0.39	–	–
Crude protein	77.36 ± 0.03[a]	77.97 ± 0.52[ab]	80.09 ± 0.90[c]	79.13 ± 0.83[bc]	77.45 ± 0.44[a]	0.016	0.725	0.003
Crude lipid	12.63 ± 0.07[b]	10.23 ± 0.76[a]	10.86 ± 0.25[a]	10.09 ± 0.27[a]	9.77 ± 0.52[a]	0.008	0.004	0.040
Ash	4.91 ± 0.34	5.11 ± 0.11	5.10 ± 0.10	5.12 ± 0.15	5.13 ± 0.02	0.568	–	–
Liver								
Moisture	58.64 ± 2.59[b]	57.55 ± 1.31[b]	52.74 ± 2.24[a]	54.50 ± 1.73[ab]	54.85 ± 2.50[ab]	0.04	0.037	0.038
Crude protein	23.57 ± 0.32[e]	21.50 ± 0.11[d]	20.14 ± 0.17[b]	17.99 ± 0.17[a]	20.57 ± 0.12[c]	0	0	0
Crude lipid	26.91 ± 0.34[c]	28.41 ± 0.34[d]	24.18 ± 0.14[b]	22.51 ± 0.24[a]	26.44 ± 0.20[c]	0	0	0

结 果

Effects of dietary *Lycium barbarum* extract on amino acid composition in the muscle of hybrid grouper (% /dry mass).

Amino acids	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	ANOVA (*P*)	Linear trend (*P*)	Quadratic trend (*P*)
	0	0.50	1.00	2.00	10.00			
Valine	2.63 ± 0.08^{a}	2.85 ± 0.10^{bc}	3.04 ± 0.05^{c}	2.80 ± 0.03^{ab}	2.99 ± 0.15^{bc}	0.003	0.002	0.717
Methionine	2.55 ± 0.11^{a}	2.78 ± 0.09^{bc}	2.94 ± 0.01^{cd}	2.68 ± 0.10^{ab}	3.01 ± 0.08^{d}	0.03	0.014	0.076
Isoleucine	1.66 ± 0.11^{a}	1.89 ± 0.13^{b}	1.99 ± 0.04^{b}	1.87 ± 0.04^{ab}	1.97 ± 0.11^{b}	0.014	0.012	0.460
Leucine	2.94 ± 0.13^{a}	3.09 ± 0.16^{a}	3.68 ± 0.25^{b}	3.15 ± 0.12^{a}	3.58 ± 0.16^{b}	0.012	0.004	0.969
Phenylalanine	5.47 ± 0.28^{a}	5.60 ± 0.37^{a}	6.37 ± 0.08^{b}	5.79 ± 0.14^{a}	6.51 ± 0.21^{b}	0.163	0.018	0.968
Arginine	2.55 ± 0.13^{a}	2.69 ± 0.15^{ab}	2.72 ± 0.29^{ab}	2.80 ± 0.11^{ab}	3.00 ± 0.26^{b}	0.018	0.018	0.306
Histidine	4.18 ± 0.14^{a}	4.56 ± 0.19^{abc}	4.87 ± 0.05^{c}	4.40 ± 0.13^{ab}	4.77 ± 0.31^{bc}	0.01	0.004	0.644
Lysine	1.33 ± 0.09^{a}	1.53 ± 0.01^{b}	1.37 ± 0.05^{a}	1.44 ± 0.05^{ab}	1.56 ± 0.07^{b}	0.014	0.018	0.005
Threonine	9.56 ± 0.35^{a}	9.98 ± 0.06^{ab}	10.85 ± 0.03^{c}	10.61 ± 0.05^{c}	10.31 ± 0.38^{bc}	0.006	0.004	0.135
Aspartic acid	4.96 ± 0.17^{a}	5.22 ± 0.09^{ab}	5.41 ± 0.30^{b}	5.19 ± 0.06^{ab}	5.58 ± 0.30^{b}	0.041	0.009	0.750
Serine	2.19 ± 0.03	2.34 ± 0.11	2.36 ± 0.15	2.28 ± 0.08	2.37 ± 0.08	0.198	–	–
Glutamic acid	5.12 ± 0.08^{a}	5.61 ± 0.10^{bc}	5.83 ± 0.09^{c}	5.52 ± 0.10^{b}	5.46 ± 0.16^{b}	0.001	0.017	0.001
Proline	2.17 ± 0.08	2.21 ± 0.17	2.28 ± 0.30	2.29 ± 0.10	2.40 ± 0.21	0.625	–	–
Glycine	2.88 ± 0.13^{a}	3.04 ± 0.18^{ab}	3.24 ± 0.14^{bc}	3.19 ± 0.11^{bc}	3.34 ± 0.13^{c}	0.021	0.002	0.234
Alanine	3.39 ± 0.24	3.61 ± 0.35	3.83 ± 0.38	3.44 ± 0.10	3.76 ± 0.19	0.266	–	–
Tyrosine	1.99 ± 0.04^{a}	2.36 ± 0.11^{c}	2.40 ± 0.01^{c}	2.12 ± 0.09^{ab}	2.29 ± 0.14^{bc}	0.006	0.042	0.075
Total AA	55.49 ± 2.08^{a}	58.56 ± 2.37^{a}	63.80 ± 0.80^{b}	59.22 ± 1.43^{a}	65.25 ± 1.77^{b}	0.077	–	–
Total EAA	32.87 ± 1.32^{a}	34.81 ± 1.15^{ab}	37.97 ± 0.44^{cd}	35.90 ± 0.06^{bc}	39.19 ± 1.65^{d}	0.012	0.002	0.295
Total NEAA	22.70 ± 0.55^{a}	24.15 ± 1.10^{b}	25.83 ± 0.36^{c}	24.03 ± 0.36^{ab}	26.06 ± 0.14^{c}	0.003	0.001	0.320
DAA	10.08 ± 0.15^{a}	10.69 ± 0.34^{b}	11.40 ± 0.25^{c}	10.71 ± 0.05^{b}	10.93 ± 0.48^{bc}	0.007	0.013	0.018

Values are means ± SD (n = 3) of three replications. Means in the same raw with different superscripts are significantly different ($P < .05$).
Total AA: total amino acid; Total EAA: total essential amino acid; Total NEAA: total non-essential amino acid; DAA: delicious amino acid.

结　果

Table 7
Effects of dietary *Lycium barbarum* extract on fatty acid composition in the muscle of hybrid grouper (% /dry mass).

ΣSFA	52.47 ± 0.71[ab]	52.88 ± 1.04[ab]	50.80 ± 1.57[a]	51.55 ± 0.63[ab]	53.08 ± 1.09[b]	0.153	0.659	0.047
ΣMUFA	19.07 ± 0.48[b]	17.87 ± 0.82[ab]	18.15 ± 0.89[ab]	17.89 ± 0.58[ab]	17.50 ± 0.11[a]	0.103	0.026	0.371
ΣPUFA	28.46 ± 0.53[a]	29.02 ± 0.02[a]	30.63 ± 0.81[b]	30.56 ± 0.79[b]	29.91 ± 0.83[ab]	0.027	0.015	0.019
Σn-3	10.73 ± 0.05	11.49 ± 0.38	11.65 ± 0.53	11.51 ± 1.30	11.39 ± 0.59	0.791	–	–
Σn-6	17.45 ± 0.49[a]	17.53 ± 0.40[a]	18.98 ± 0.29[b]	19.04 ± 0.61[b]	18.81 ± 0.41[b]	0.014	0.004	0.043
USFA/SFA	0.91 ± 0.03	0.89 ± 0.04	0.92 ± 0.10	0.94 ± 0.02	0.89 ± 0.04	0.782	–	–
PUFA/SFA	0.54 ± 0.02	0.55 ± 0.01	0.60 ± 0.03	0.59 ± 0.02	0.55 ± 0.03	0.071	–	–
n-6/n-3	1.54 ± 0.07[a]	1.60 ± 0.01[ab]	1.66 ± 0.06[ab]	1.80 ± 0.08[c]	1.70 ± 0.03[bc]	0.024	–	–

Fatty acids	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	ANOVA (*P*)	Linear trend (*P*)	Quadratic trend (*P*)
	0	0.50	1.00	2.00	10.00			
C14:0	5.28 ± 0.23[b]	4.78 ± 0.00[a]	4.55 ± 0.03[a]	4.66 ± 0.15[a]	4.58 ± 0.08[a]	0.012	0.005	0.014
C15:0	0.50 ± 0.01	0.49 ± 0.05	0.51 ± 0.03	0.47 ± 0.05	0.50 ± 0.01	0.704	–	–
C16:0	35.79 ± 0.99[ab]	36.83 ± 2.01[b]	33.16 ± 1.73[a]	34.50 ± 0.84[ab]	35.41 ± 0.75[ab]	0.097	–	–
C18:0	10.09 ± 0.37[a]	11.48 ± 0.44[b]	11.79 ± 0.39[b]	11.36 ± 0.37[b]	11.32 ± 0.12[b]	0.005	0.014	0.004
C20:0	0.51 ± 0.02	0.52 ± 0.07	0.60 ± 0.10	0.50 ± 0.09	0.47 ± 0.08	0.425	–	–
C22:0	0.25 ± 0.02	0.27 ± 0.00	0.31 ± 0.06	0.29 ± 0.03	0.26 ± 0.01	0.338	0.691	0.073
C23:0	0.05 ± 0.01	0.07 ± 0.00	0.06 ± 0.02	0.07 ± 0.01	0.06 ± 0.00	0.408	–	–
C20:4n6 (ARA)	0.35 ± 0.03	0.41 ± 0.05	0.39 ± 0.05	[illegible]36 ± 0.04	0.46 ± 0.10	0.242	–	–
C20:5n3 (EPA)	2.42 ± 0.17	2.27 ± 0.19	2.38 ± 0.22	[illegible]33 ± 0.29	2.31 ± 0.07	0.888	–	–
C22:5n3 (DPA)	1.08 ± 0.09	1.00 ± 0.07	1.07 ± 0.10	[illegible]04 ± 0.10	1.04 ± 0.06	0.824	–	–
C22:6n3 (DHA)	4.86 ± 0.11	4.97 ± 0.17	5.00 ± 0.32	[illegible]92 ± 0.43	5.39 ± 0.32	0.392	–	–
ΣSFA	52.47 ± 0.71[ab]	52.88 ± 1.04[ab]	50.80 ± 1.57[a]	51.55 ± 0.63[ab]	53.08 ± 1.09[b]	0.153	0.659	0.047
ΣMUFA	19.07 ± 0.48[b]	17.87 ± 0.82[ab]	18.15 ± 0.89[ab]	17.89 ± 0.58[ab]	17.50 ± 0.11[a]	0.103	0.026	0.371
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Σn-6	17.45 ± 0.49[a]	17.53 ± 0.40[a]	18.98 ± 0.29[b]	19.04 ± 0.61[b]	18.81 ± 0.41[b]	0.014	0.004	0.043
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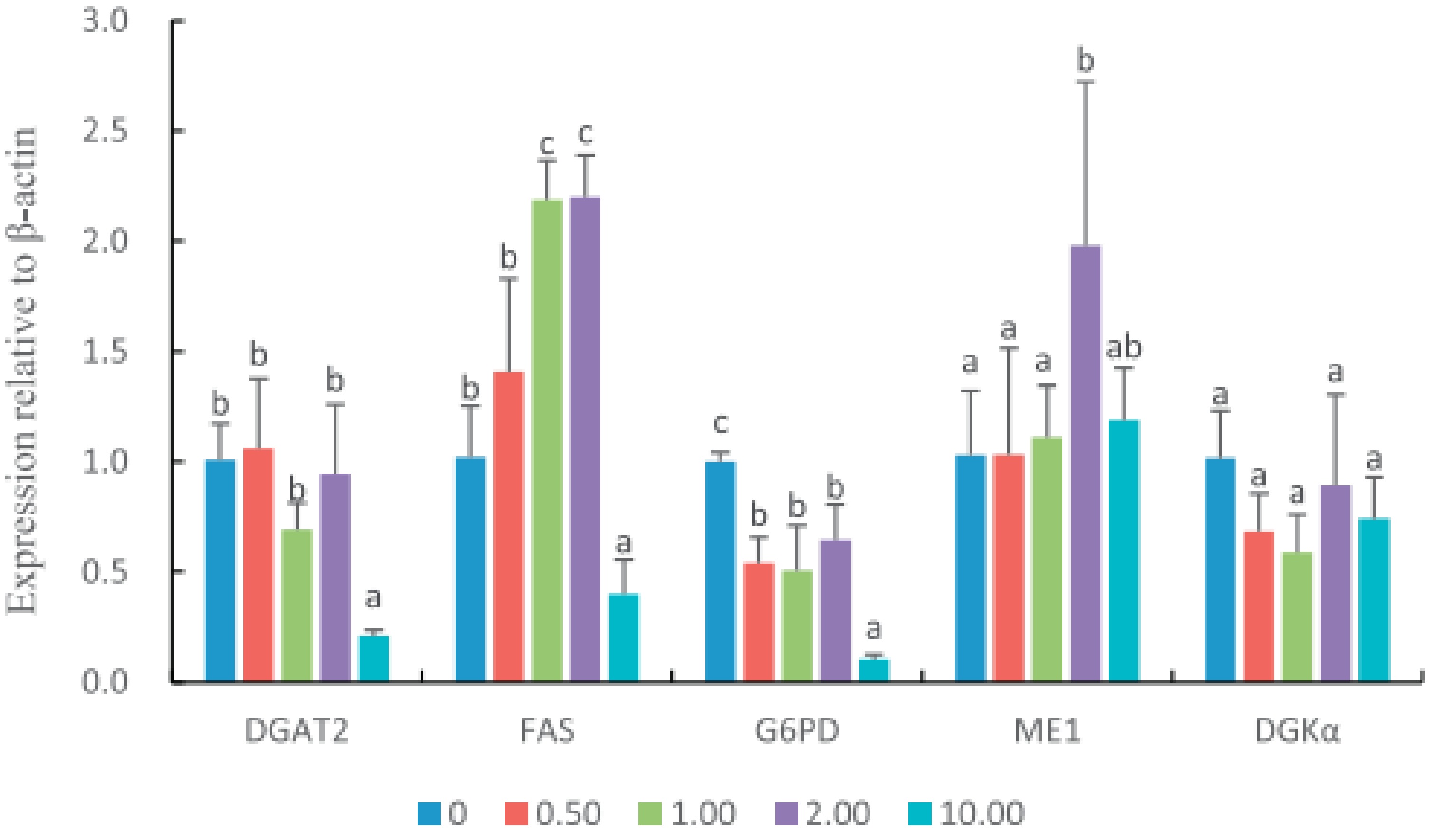
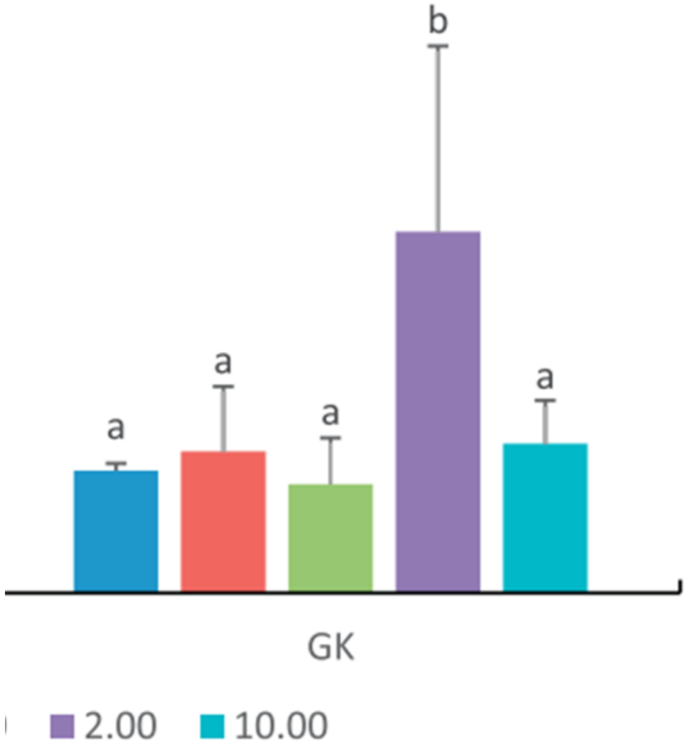
PUFA/SFA	0.54 ± 0.02	0.55 ± 0.01	0.60 ± 0.03	0.59 ± 0.02	0.55 ± 0.03	0.071	–	–
n-6/n-3	1.54 ± 0.07[a]	1.60 ± 0.01[ab]	1.66 ± 0.06[ab]	1.80 ± 0.08[c]	1.70 ± 0.03[bc]	0.024	–	–

Values are means ± SD (n = 3) of three replications. Means in the same raw with different superscripts are significantly different ($P < .05$).
ΣSFA: saturated fatty acid; ΣMUFA: mono-unsaturated fatty acid; ΣPUFA: poly-unsaturated fatty acid; Σn-3: total omega 3 fatty acid; Σn-6: total omega 6 fatty acid.

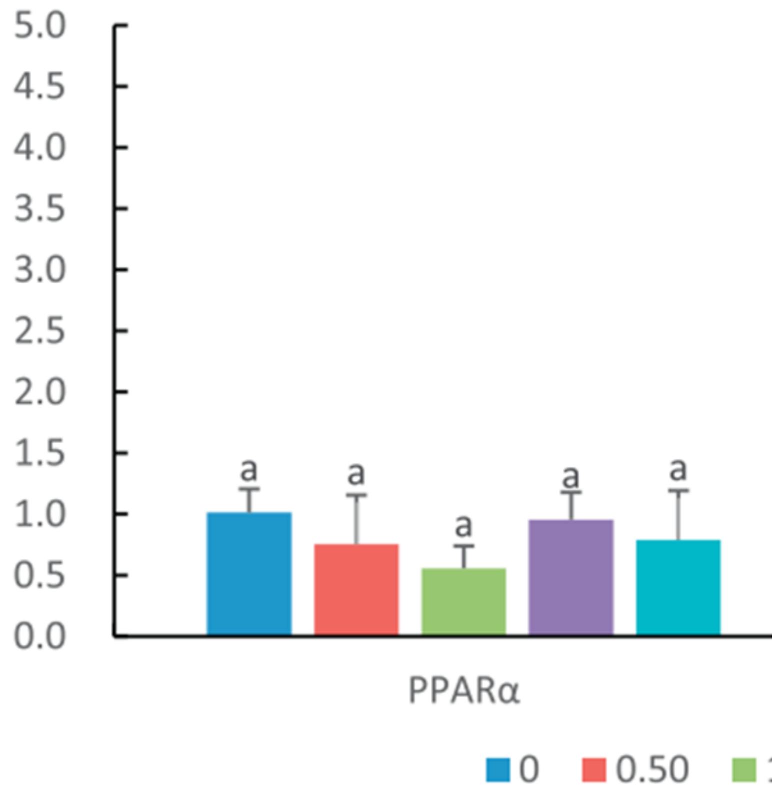
结　果

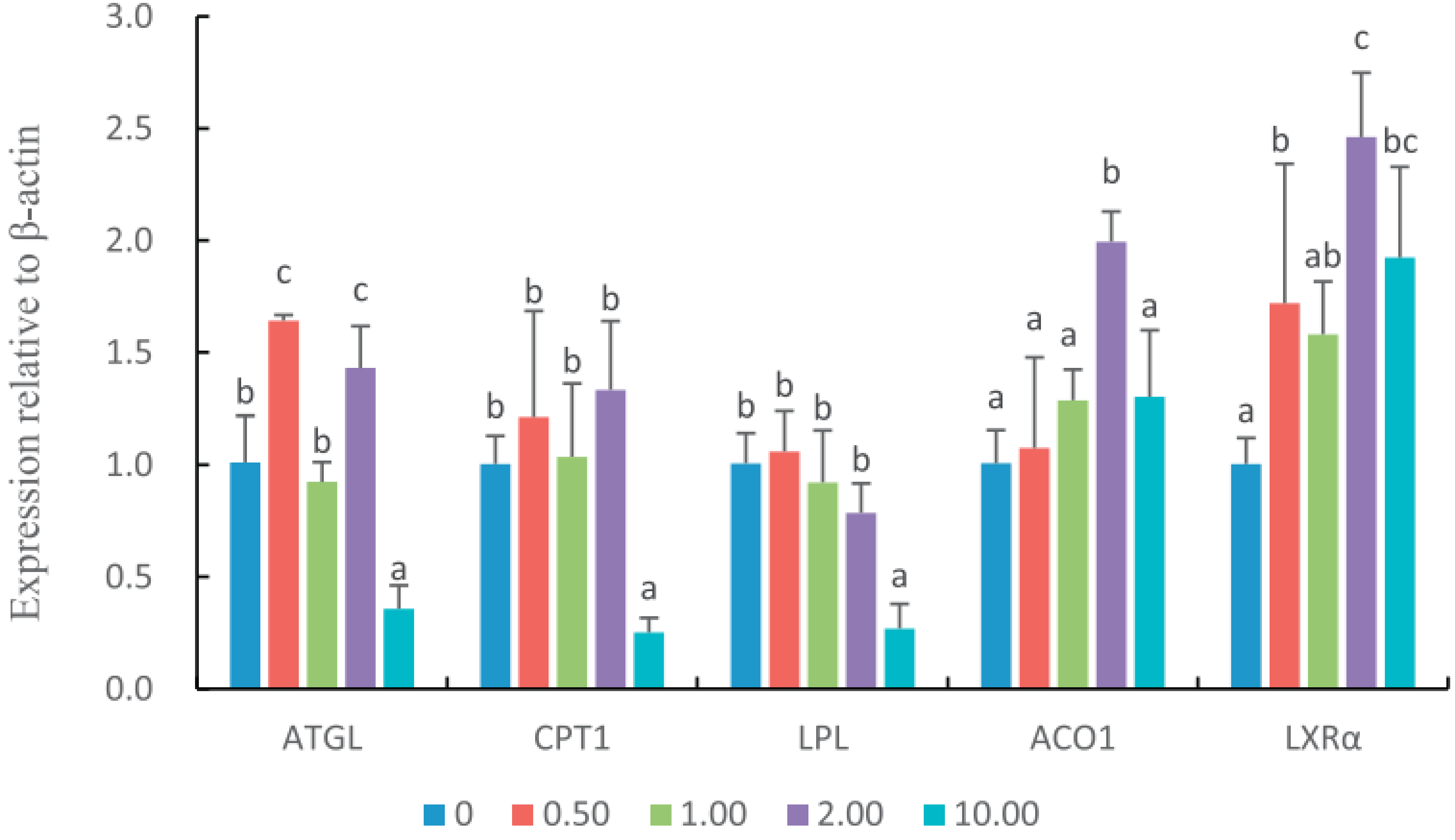




脂质合成相关基因的表达情况

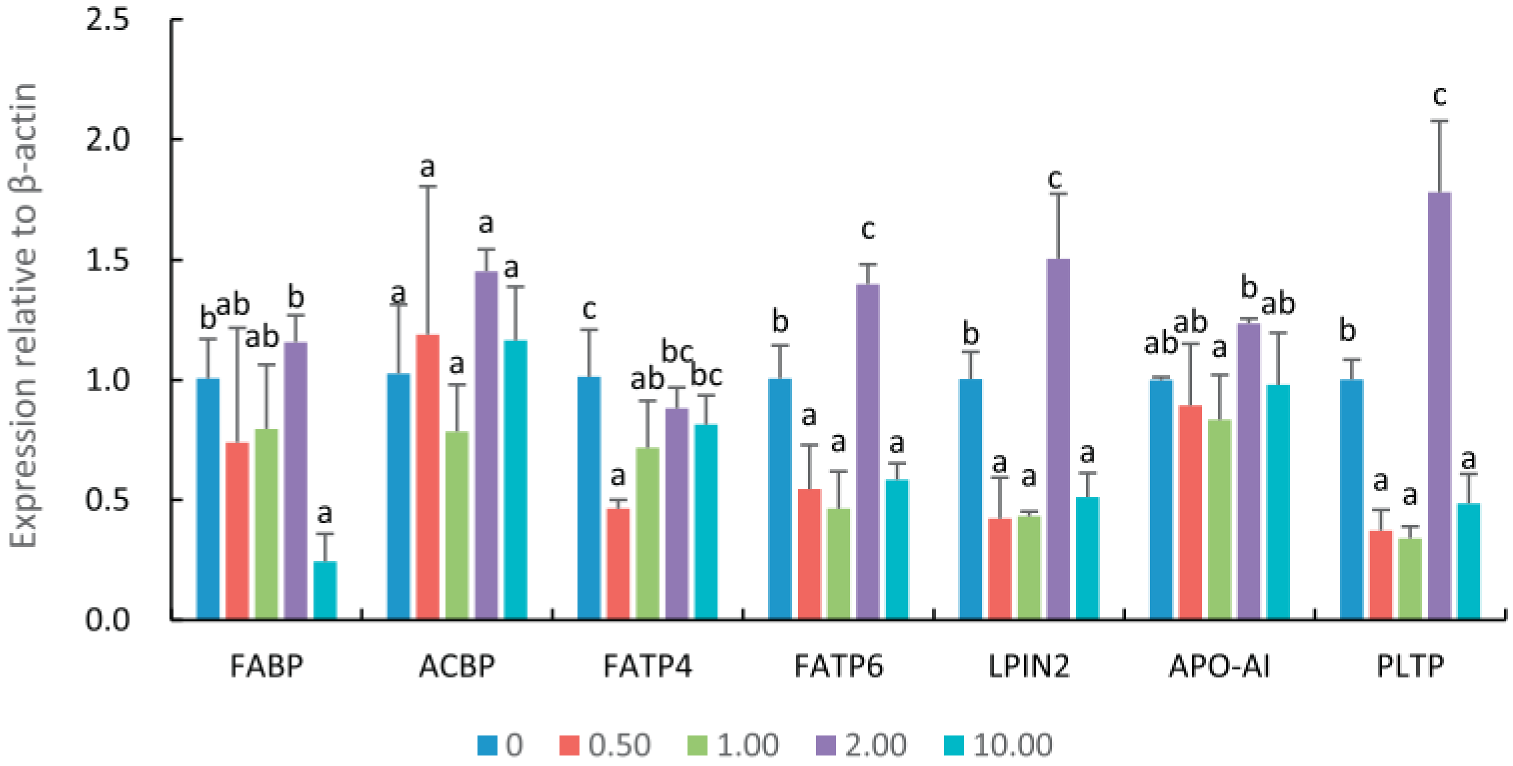
结　果





脂肪分解相关基因的表达情况

结　果


Expression relative to β-actin
0.0
0.5
1.0
1.5
2.0
2.5
FABP
ACBP
FATP4
FATP6
LPIN2
APO-AI
PLTP
b ab ab b a
a a a a a
c a ab bc bc
b a a c a
b a a c a
ab ab a b ab
b a a c a
0
0.50
1.00
2.00
10.00

第四章

讨论

[redacted]

讨　论

目前的研究表明，饮食补充0.5-10 g kg−1的LBE通过蛋白保留效应改善了高脂饲料喂养的杂交石斑鱼的生长性能和蛋白沉积。

饮食中的LBE通过降低血浆CHO、TG和LDL来降低氧化应激，通过改善肌肉中的肉类成分、氨基酸和脂肪酸分布来改善肉质。

膳食中的LBE通过调节脂质代谢相关基因表达，抑制脂质沉积，改善脂质代谢葡素可以增强鱼体免疫及其抗氧化性。

敬请各位老师批评指正