



河南师范大学

NENAN NORMAL UNIVERSITY

# 读书报告

汇报人 于若梦

日期 2019.1.2



Contents lists available at ScienceDirect

## Aquaculture

journal homepage: [www.elsevier.com/locate/aquaculture](http://www.elsevier.com/locate/aquaculture)



Lipid contents in farmed fish are influenced by dietary DHA/EPA ratio: A study with the marine flatfish, tongue sole (*Cynoglossus semilaevis*)



Houguo Xu<sup>a</sup>, Lin Cao<sup>a</sup>, Yuliang Wei<sup>a</sup>, Yuanqin Zhang<sup>a</sup>, Mengqing Liang<sup>a,b,\*</sup>

<sup>a</sup> Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, 106 Nanjing Road, Qingdao 266071, China

<sup>b</sup> Laboratory for Marine Fisheries Science and Food Production Processes, Qingdao National Laboratory for Marine Science and Technology, 1 Wenhai Road, Qingdao 266237, China

# 目录

## CONTENTS

1 研究背景

2 材料与方法

3 结果

4 讨论

## 研究背景-DHA、EPA

◆ **LC-PUFA**:碳链原子数  $\geq 20$ 、不饱和双键  $\geq 3$  的PUFA叫做长链多不饱和脂肪(Long-chain polyunsaturated fatty acids, LC-PUFA)  
例如: **DHA** (22:6n-3)、**EPA** (20:5n-3)。

### ◆ **LC-PUFA**的主要功能

有促进视网膜、大脑和神经系统的发育,降低心血管疾病和炎症的发生,增强机体免疫力等多种生理作用。DHA对大脑的正常发育,尤其是对大脑皮层和视网膜的发育,具有重要意义。



## 研究背景-半滑舌鳎

### ◆ 半滑舌鳎 (*Cynoglossus semilaevis* Gunther)

属鲽形目、舌鳎科、舌鳎属，俗称“龙脷”、牛舌头、鳎目、鳎板、鰆鳎、细鳞、鳎米。是一种暖温性近海大型底层鱼类，终年生活栖息在中国近海海区，具广温、广盐和适应多变的环境条件的特点，适温范围3.5—32℃，最适水温14—24℃，适盐范围14-33‰。半滑舌鳎自然资源量少，味鲜鲜美，出肉率高，口感爽滑，鱼肉久煮而不老，无腥味和异味，属于高蛋白，营养丰富。



## 材料与amp;方法

- ◆ 饲料
- ◆ 实验鱼/养殖
- ◆ 脂肪和脂肪酸组成分析
- ◆ 鱼类组织脂质代谢相关蛋白mRNA表达分析
- ◆ 统计方法

# 材料与amp;方法--饲料

**Table 1**  
Formulation and proximate composition of the experiment diets (g/kg dry matter).

Ingredient	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
Fish meal	400.0	400.0	400.0	400.0	400.0	400.0
Soybean meal	200.0	200.0	200.0	200.0	200.0	200.0
Wheat gluten	120.0	120.0	120.0	120.0	120.0	120.0
Wheat meal	144.0	144.0	144.0	144.0	144.0	144.0
Vitamin premix <sup>a</sup>	10.0	10.0	10.0	10.0	10.0	10.0
Mineral premix <sup>b</sup>	10.0	10.0	10.0	10.0	10.0	10.0
Monocalcium phosphate	10.0	10.0	10.0	10.0	10.0	10.0
Choline chloride	10.0	10.0	10.0	10.0	10.0	10.0
L-Ascorbyl-2-polyphosphate	2.0	2.0	2.0	2.0	2.0	2.0
Ethoxyquin	0.5	0.5	0.5	0.5	0.5	0.5
Soy lecithin	20.0	20.0	20.0	20.0	20.0	20.0
Soybean oil	15.0	15.0	15.0	15.0	15.0	15.0
ARA enriched oil <sup>c</sup>	6.0	6.0	6.0	6.0	6.0	6.0
Olive oil	18.6	20.3	21.2	21.9	22.4	22.7
EPA enriched oil <sup>d</sup>	29.9	20.0	14.0	10.0	7.1	5.0
DHA enriched oil <sup>e</sup>	4.0	12.2	17.3	20.6	23.0	24.8
Proximate composition						
Crude protein	531.1	529.1	532.2	534.1	530.2	533.7
Crude lipid	118.2	120.0	119.2	122.0	123.5	121.6
Ash	114.1	115.3	114.6	112.7	115.0	114.4

**Table 2**  
Fatty acid compositions of the experimental diets (% total fatty acids).

Fatty acid	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
C14:0	1.36	1.29	1.35	1.40	1.32	1.36
C16:0	13.68	13.37	14.02	14.08	14.16	13.96
C18:0	3.88	3.73	3.77	3.85	3.74	3.67
ΣSFA	18.93	18.38	19.15	19.33	19.23	18.98
C16:1n-7	1.52	1.57	1.56	1.53	1.55	1.64
C18:1n-9	20.72	20.99	21.79	22.01	22.34	21.83
C18:1n-7	2.14	2.01	1.99	1.87	1.85	1.81
ΣMUFA	24.37	24.58	25.35	25.41	25.74	25.27
C18:2n-6	21.18	20.93	21.19	21.22	21.41	21.15
C20:4n-6	3.69	3.42	3.15	3.03	2.94	2.91
Σn-6 PUFA	24.87	24.35	24.34	24.26	24.35	24.07
C18:3n-3	2.27	2.34	2.22	2.14	2.18	2.24
C20:5n-3	13.92	11.37	8.94	7.52	6.62	5.93
C22:5n-3	1.36	1.82	2.03	2.29	2.41	2.43
C22:6n-3	8.54	11.59	13.06	14.34	15.35	16.32
Σn-3 PUFA	26.10	27.12	26.25	26.28	26.56	26.92
Σn-3 LC-PUFA	23.83	24.78	24.03	24.15	24.38	24.68
Σn-3/Σn-6	1.05	1.11	1.08	1.08	1.09	1.12
DHA/EPA	0.61	1.02	1.46	1.91	2.32	2.75

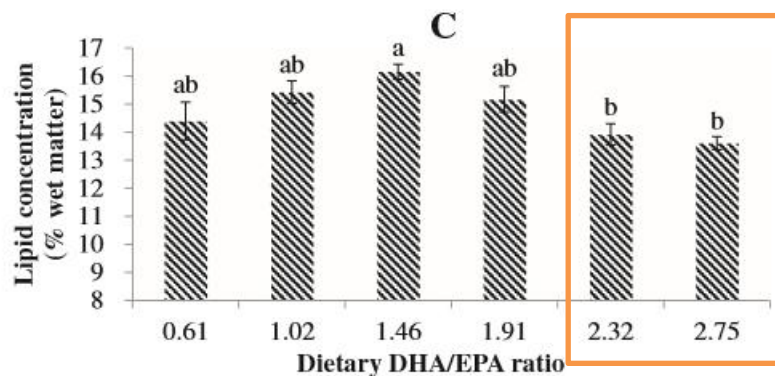
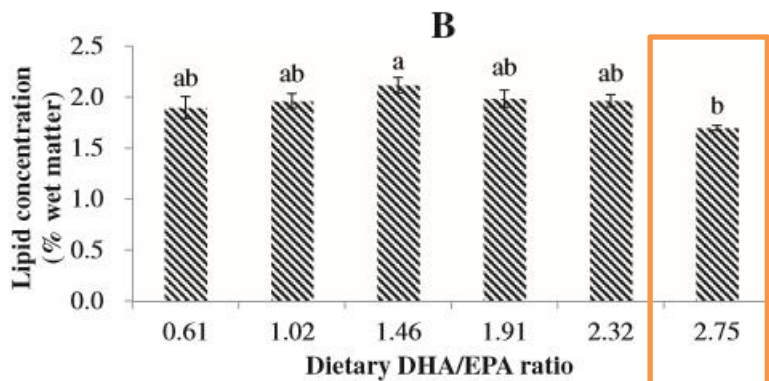
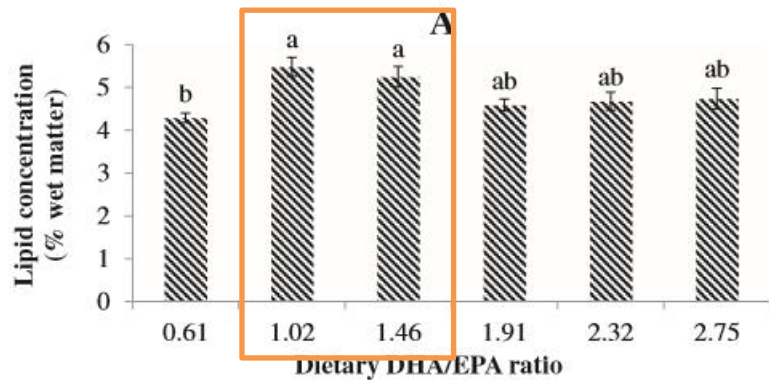
SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; LC-PUFA: long chain-polyunsaturated fatty acid.



## 材料与amp;方法--实验鱼/养殖

- 1.实验鱼：半滑舌鳎（ $23.40 \pm 0.45$ 克）
- 2.养殖条件：玻璃缸（80厘米×80厘米×80厘米）
- 3.暂养：商用饲料，14天，以适应试验条件
- 4.投喂：每日两次，饱食投喂（80天）

# 結果



**Fig. 1.** Effects of dietary DHA/EPA ratio on the lipid concentration in whole body (A), muscle (B), and liver (C) of tongue sole. Values (means  $\pm$  standard error,  $n = 3$ ) in bars that do not have the same letter are significantly different ( $P < 0.05$ ).

# 結果

**Table 4**

Muscle fatty acid compositions of tongue sole fed the experimental diets (% total fatty acids, means  $\pm$  standard error, n = 3).

Fatty acid	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
C14:0	1.31 $\pm$ 0.06	1.69 $\pm$ 0.19	1.47 $\pm$ 0.20	1.31 $\pm$ 0.21	1.52 $\pm$ 0.25	1.62 $\pm$ 0.35
C16:0	18.18 $\pm$ 0.31	16.84 $\pm$ 0.21	16.88 $\pm$ 0.82	17.21 $\pm$ 0.45	16.15 $\pm$ 0.33	17.29 $\pm$ 0.44
C18:0	8.37 $\pm$ 0.87	5.24 $\pm$ 0.60	6.66 $\pm$ 1.35	7.00 $\pm$ 1.68	4.84 $\pm$ 0.05	6.44 $\pm$ 1.53
$\Sigma$ SFA	27.86 $\pm$ 1.21	23.77 $\pm$ 0.62	25.01 $\pm$ 1.89	25.53 $\pm$ 1.92	22.50 $\pm$ 0.62	25.25 $\pm$ 1.62
C16:1n-7	1.85 $\pm$ 0.07	2.71 $\pm$ 0.23	2.19 $\pm$ 0.19	2.00 $\pm$ 0.44	2.38 $\pm$ 0.29	2.46 $\pm$ 0.55
C18:1n-9	20.67 $\pm$ 0.44	22.05 $\pm$ 0.28	21.20 $\pm$ 0.80	22.12 $\pm$ 0.95	24.23 $\pm$ 0.56	20.53 $\pm$ 1.57
C18:1n-7	2.94 $\pm$ 0.05 <sup>a</sup>	2.84 $\pm$ 0.04 <sup>ab</sup>	2.69 $\pm$ 0.03 <sup>ab</sup>	2.63 $\pm$ 0.06 <sup>ab</sup>	2.53 $\pm$ 0.14 <sup>b</sup>	2.58 $\pm$ 0.04 <sup>b</sup>
$\Sigma$ MUFA	25.46 $\pm$ 0.52	27.59 $\pm$ 0.02	26.38 $\pm$ 1.31	26.74 $\pm$ 1.40	29.14 $\pm$ 0.14	27.57 $\pm$ 2.14
C18:2n-6	15.23 $\pm$ 0.51	16.84 $\pm$ 0.20	16.14 $\pm$ 0.68	16.38 $\pm$ 0.47	17.35 $\pm$ 0.56	16.04 $\pm$ 0.26
C20:4n-6	3.73 $\pm$ 0.01	3.04 $\pm$ 0.14	3.32 $\pm$ 0.25	3.10 $\pm$ 0.36	2.46 $\pm$ 0.07	3.10 $\pm$ 0.35
$\Sigma$ n-6 PUFA	18.95 $\pm$ 0.51	19.87 $\pm$ 0.34	19.46 $\pm$ 0.50	19.48 $\pm$ 0.11	19.81 $\pm$ 0.63	19.13 $\pm$ 0.38
C18:3n-3	1.16 $\pm$ 0.09	1.54 $\pm$ 0.08	1.29 $\pm$ 0.16	1.21 $\pm$ 0.18	1.44 $\pm$ 0.02	1.31 $\pm$ 0.15
C20:5n-3	7.57 $\pm$ 0.12 <sup>a</sup>	6.03 $\pm$ 0.23 <sup>b</sup>	4.71 $\pm$ 0.03 <sup>c</sup>	4.14 $\pm$ 0.15 <sup>c</sup>	3.85 $\pm$ 0.22 <sup>c</sup>	4.13 $\pm$ 0.07 <sup>c</sup>
C22:5n-3	3.18 $\pm$ 0.13	3.56 $\pm$ 0.27	3.20 $\pm$ 0.32	3.39 $\pm$ 0.17	3.34 $\pm$ 0.03	3.28 $\pm$ 0.14
C22:6n-3	9.59 $\pm$ 0.31 <sup>d</sup>	11.79 $\pm$ 0.38 <sup>c</sup>	12.95 $\pm$ 0.49 <sup>bc</sup>	14.14 $\pm$ 0.33 <sup>ab</sup>	13.40 $\pm$ 0.10 <sup>bc</sup>	15.31 $\pm$ 0.49 <sup>a</sup>
$\Sigma$ n-3 PUFA	21.52 $\pm$ 0.27 <sup>b</sup>	22.93 $\pm$ 0.77 <sup>ab</sup>	21.68 $\pm$ 0.34 <sup>ab</sup>	22.88 $\pm$ 0.35 <sup>ab</sup>	22.03 $\pm$ 0.28 <sup>ab</sup>	24.04 $\pm$ 0.08 <sup>a</sup>
$\Sigma$ n-3/ $\Sigma$ n-6	1.14 $\pm$ 0.03	1.16 $\pm$ 0.06	1.14 $\pm$ 0.05	1.17 $\pm$ 0.02	1.11 $\pm$ 0.05	1.25 $\pm$ 0.04
DHA/EPA	1.27 $\pm$ 0.06 <sup>d</sup>	1.96 $\pm$ 0.06 <sup>c</sup>	2.76 $\pm$ 0.12 <sup>b</sup>	3.43 $\pm$ 0.13 <sup>a</sup>	3.49 $\pm$ 0.18 <sup>a</sup>	3.72 $\pm$ 0.19 <sup>a</sup>
$\Sigma$ n-3 LC-PUFA	20.36 $\pm$ 0.24 <sup>b</sup>	21.38 $\pm$ 0.70 <sup>ab</sup>	20.54 $\pm$ 0.41 <sup>ab</sup>	21.67 $\pm$ 0.29 <sup>ab</sup>	20.59 $\pm$ 0.29 <sup>ab</sup>	22.70 $\pm$ 0.18 <sup>a</sup>

Values in the same row with different superscript letters are significantly different ( $P < 0.05$ ). SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; LC-PUFA: long chain-polyunsaturated fatty acid.

# 結果

**Table 5**

Liver fatty acid compositions of tongue sole fed the experimental diets (% total fatty acids, means  $\pm$  standard error, n = 3).

Fatty acid	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
C14:0	0.75 $\pm$ 0.03	0.75 $\pm$ 0.03	0.67 $\pm$ 0.01	0.73 $\pm$ 0.01	0.75 $\pm$ 0.01	0.79 $\pm$ 0.06
C16:0	17.84 $\pm$ 0.28	18.27 $\pm$ 0.28	17.97 $\pm$ 0.21	17.72 $\pm$ 0.24	18.12 $\pm$ 0.18	17.28 $\pm$ 0.57
C18:0	17.52 $\pm$ 0.94 <sup>ab</sup>	17.11 $\pm$ 0.13 <sup>ab</sup>	19.14 $\pm$ 0.36 <sup>a</sup>	17.26 $\pm$ 1.31 <sup>ab</sup>	16.34 $\pm$ 0.83 <sup>ab</sup>	14.18 $\pm$ 0.25 <sup>b</sup>
$\Sigma$ SFA	36.10 $\pm$ 1.01 <sup>ab</sup>	36.13 $\pm$ 0.36 <sup>ab</sup>	37.78 $\pm$ 0.17 <sup>a</sup>	35.77 $\pm$ 1.57 <sup>ab</sup>	35.21 $\pm$ 0.79 <sup>ab</sup>	32.25 $\pm$ 0.30 <sup>b</sup>
C16:1n-7	0.56 $\pm$ 0.04	0.69 $\pm$ 0.02	0.63 $\pm$ 0.08	0.59 $\pm$ 0.10	0.59 $\pm$ 0.03	0.73 $\pm$ 0.12
C18:1n-9	12.29 $\pm$ 0.80	14.40 $\pm$ 0.41	12.90 $\pm$ 0.26	13.20 $\pm$ 0.30	13.87 $\pm$ 0.18	13.36 $\pm$ 0.78
C18:1n-7	2.15 $\pm$ 0.09 <sup>a</sup>	2.08 $\pm$ 0.04 <sup>ab</sup>	2.01 $\pm$ 0.04 <sup>ab</sup>	1.84 $\pm$ 0.03 <sup>b</sup>	1.82 $\pm$ 0.04 <sup>b</sup>	1.83 $\pm$ 0.08 <sup>b</sup>
$\Sigma$ MUFA	15.00 $\pm$ 0.90	17.17 $\pm$ 0.45	15.53 $\pm$ 0.28	15.63 $\pm$ 0.39	16.27 $\pm$ 0.20	15.92 $\pm$ 0.96
C18:2n-6	11.19 $\pm$ 0.57	12.09 $\pm$ 0.00	10.94 $\pm$ 0.23	12.61 $\pm$ 0.65	12.60 $\pm$ 0.14	13.05 $\pm$ 0.84
C20:4n-6	7.19 $\pm$ 0.30	6.28 $\pm$ 0.02	6.75 $\pm$ 0.20	6.87 $\pm$ 0.07	6.54 $\pm$ 0.20	6.89 $\pm$ 0.30
$\Sigma$ n-6 PUFA	18.39 $\pm$ 0.57	18.38 $\pm$ 0.02	17.68 $\pm$ 0.36	19.48 $\pm$ 0.70	19.14 $\pm$ 0.32	19.94 $\pm$ 0.60
C18:3n-3	0.47 $\pm$ 0.07	0.52 $\pm$ 0.01	0.40 $\pm$ 0.03	0.47 $\pm$ 0.06	0.49 $\pm$ 0.04	0.60 $\pm$ 0.12
C20:5n-3	7.56 $\pm$ 0.29 <sup>a</sup>	5.21 $\pm$ 0.05 <sup>b</sup>	4.41 $\pm$ 0.04 <sup>bc</sup>	4.34 $\pm$ 0.13 <sup>bc</sup>	3.99 $\pm$ 0.14 <sup>c</sup>	4.22 $\pm$ 0.17 <sup>bc</sup>
C22:5n-3	2.35 $\pm$ 0.14	2.46 $\pm$ 0.03	1.76 $\pm$ 0.09	2.20 $\pm$ 0.26	2.07 $\pm$ 0.09	2.24 $\pm$ 0.23
C22:6n-3	12.99 $\pm$ 0.93 <sup>b</sup>	13.99 $\pm$ 0.04 <sup>b</sup>	15.72 $\pm$ 1.12 <sup>ab</sup>	15.66 $\pm$ 0.28 <sup>ab</sup>	16.87 $\pm$ 1.11 <sup>ab</sup>	19.61 $\pm$ 0.47 <sup>a</sup>
$\Sigma$ n-3 PUFA	23.37 $\pm$ 1.07	22.17 $\pm$ 0.05	22.30 $\pm$ 1.44	22.66 $\pm$ 0.69	23.43 $\pm$ 1.35	26.67 $\pm$ 0.72
$\Sigma$ n-3/ $\Sigma$ n-6	1.27 $\pm$ 0.07	1.21 $\pm$ 0.00	1.26 $\pm$ 0.06	1.16 $\pm$ 0.02	1.22 $\pm$ 0.05	1.34 $\pm$ 0.03
DHA/EPA	1.71 $\pm$ 0.06 <sup>d</sup>	2.69 $\pm$ 0.04 <sup>c</sup>	3.57 $\pm$ 0.14 <sup>b</sup>	3.63 $\pm$ 0.17 <sup>b</sup>	4.21 $\pm$ 0.16 <sup>ab</sup>	4.66 $\pm$ 0.12 <sup>a</sup>
$\Sigma$ n-3 LC-PUFA	22.91 $\pm$ 1.08	21.65 $\pm$ 0.04	21.89 $\pm$ 1.43	22.19 $\pm$ 0.63	22.94 $\pm$ 1.31	26.07 $\pm$ 0.63

Values in the same row with different superscript letters are significantly different ( $P < 0.05$ ). SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; LC-PUFA: long chain-polyunsaturated fatty acid.

# 結果

**Table 6**

Lipid metabolism related indices in serum of tongue sole fed the experimental diets (means  $\pm$  standard error, n = 3).

Index	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
TG (mmol L <sup>-1</sup> )	5.75 $\pm$ 0.39 <sup>a</sup>	4.59 $\pm$ 0.23 <sup>ab</sup>	3.83 $\pm$ 0.24 <sup>b</sup>	4.53 $\pm$ 0.26 <sup>ab</sup>	4.63 $\pm$ 0.23 <sup>ab</sup>	5.26 $\pm$ 0.14 <sup>a</sup>
TC (mmol L <sup>-1</sup> )	4.36 $\pm$ 0.20	4.39 $\pm$ 0.38	3.98 $\pm$ 0.36	3.79 $\pm$ 0.04	4.48 $\pm$ 0.49	4.84 $\pm$ 0.62
HDL-C (mmol L <sup>-1</sup> )	2.84 $\pm$ 0.29 <sup>a</sup>	2.65 $\pm$ 0.21 <sup>ab</sup>	2.98 $\pm$ 0.17 <sup>a</sup>	2.36 $\pm$ 0.17 <sup>ab</sup>	1.77 $\pm$ 0.12 <sup>b</sup>	1.77 $\pm$ 0.39 <sup>b</sup>
LDL-C (mmol L <sup>-1</sup> )	1.19 $\pm$ 0.20 <sup>ab</sup>	1.03 $\pm$ 0.11 <sup>ab</sup>	0.90 $\pm$ 0.16 <sup>b</sup>	1.15 $\pm$ 0.20 <sup>ab</sup>	1.52 $\pm$ 0.22 <sup>ab</sup>	1.82 $\pm$ 0.13 <sup>a</sup>
Bile acid ( $\mu$ mol L <sup>-1</sup> )	5.68 $\pm$ 0.41	5.20 $\pm$ 0.10	5.29 $\pm$ 0.23	5.82 $\pm$ 0.17	5.69 $\pm$ 0.11	5.69 $\pm$ 0.40
MDA (nmol L <sup>-1</sup> )	17.78 $\pm$ 2.14 <sup>b</sup>	18.41 $\pm$ 3.55 <sup>b</sup>	12.90 $\pm$ 1.20 <sup>b</sup>	24.57 $\pm$ 6.71 <sup>b</sup>	71.67 $\pm$ 5.24 <sup>a</sup>	84.94 $\pm$ 0.41 <sup>a</sup>
SOD (units mL <sup>-1</sup> )	371.31 $\pm$ 9.78 <sup>a</sup>	368.83 $\pm$ 4.50 <sup>a</sup>	333.45 $\pm$ 4.49 <sup>bc</sup>	313.22 $\pm$ 7.07 <sup>c</sup>	361.08 $\pm$ 7.20 <sup>ab</sup>	338.95 $\pm$ 9.33 <sup>abc</sup>

TG: triglyceride; TC: total cholesterol; HDL-C: high density lipoprotein-cholesterol; LDL-C: low density lipoprotein-cholesterol; MDA: malondialdehyde; SOD: superoxide dismutase.

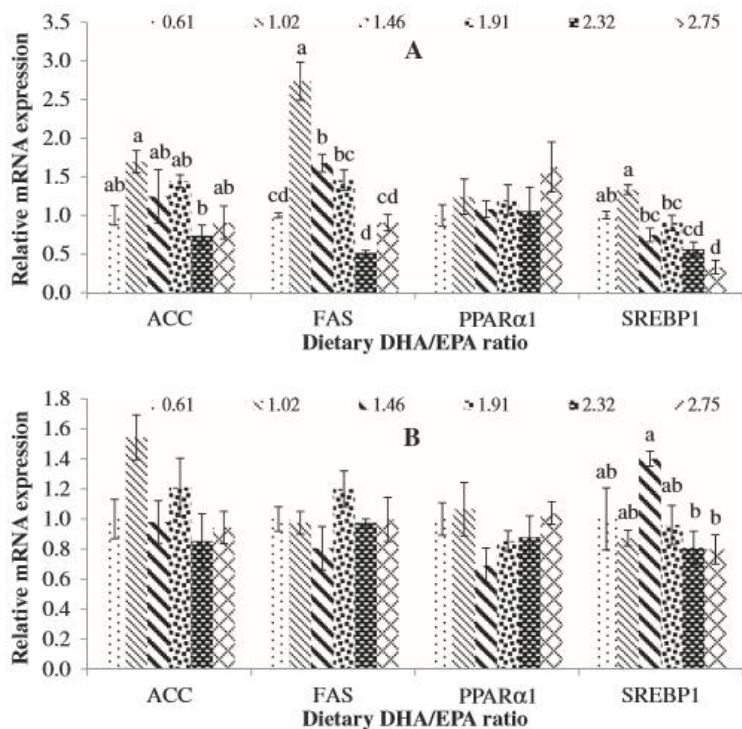
**Table 7**

Growth performances of tongue sole fed the experimental diets (means  $\pm$  standard error, n = 3).

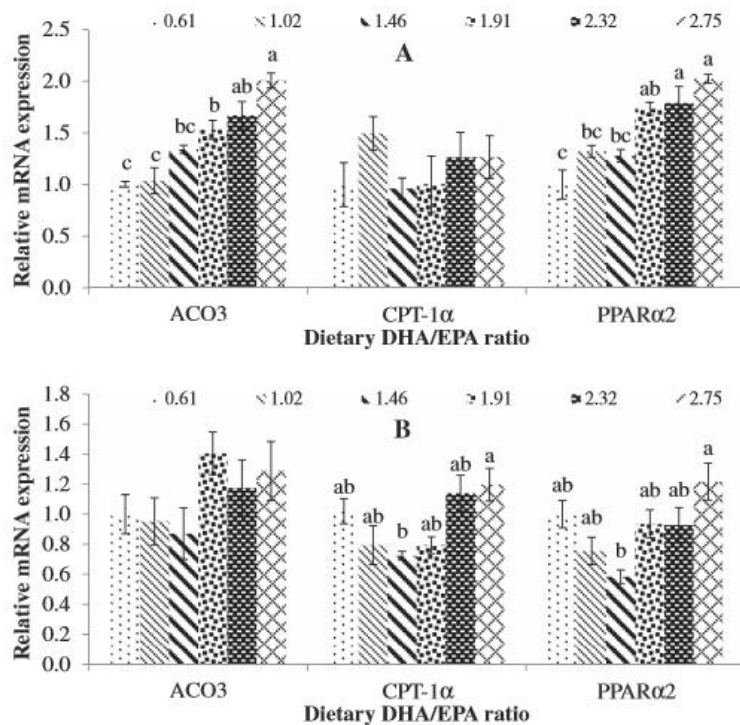
Parameter	D/E-0.61	D/E-1.02	D/E-1.46	D/E-1.91	D/E-2.32	D/E-2.75
Initial weight (g)	23.11 $\pm$ 0.01	23.31 $\pm$ 0.10	23.54 $\pm$ 0.19	23.49 $\pm$ 0.29	23.59 $\pm$ 0.19	23.34 $\pm$ 0.27
Final weight (g)	70.53 $\pm$ 0.80 <sup>c</sup>	71.32 $\pm$ 1.30 <sup>c</sup>	80.58 $\pm$ 1.92 <sup>a</sup>	79.33 $\pm$ 2.05 <sup>ab</sup>	72.14 $\pm$ 1.49 <sup>bc</sup>	71.19 $\pm$ 1.40 <sup>c</sup>
Weight gain (%)	205.09 $\pm$ 3.43 <sup>b</sup>	206.00 $\pm$ 4.93 <sup>b</sup>	242.31 $\pm$ 6.52 <sup>a</sup>	237.58 $\pm$ 4.64 <sup>a</sup>	205.83 $\pm$ 6.81 <sup>b</sup>	204.95 $\pm$ 2.76 <sup>b</sup>
Feed intake (%)	0.96 $\pm$ 0.04	0.98 $\pm$ 0.04	1.00 $\pm$ 0.05	0.99 $\pm$ 0.01	1.00 $\pm$ 0.03	0.96 $\pm$ 0.04
Feed efficiency	1.11 $\pm$ 0.02 <sup>bc</sup>	1.19 $\pm$ 0.02 <sup>ab</sup>	1.21 $\pm$ 0.01 <sup>a</sup>	1.15 $\pm$ 0.03 <sup>abc</sup>	1.13 $\pm$ 0.02 <sup>abc</sup>	1.08 $\pm$ 0.02 <sup>c</sup>
Survival (%)	83.33 $\pm$ 1.93	91.11 $\pm$ 4.01	91.11 $\pm$ 2.94	81.11 $\pm$ 4.01	87.78 $\pm$ 1.11	80.00 $\pm$ 3.33

Weight gain (%) = (Final weight - Initial weight) / Initial weight  $\times$  100; Feed intake (%) = total feed consumed  $\times$  2 / ((Final weight + Initial weight)  $\times$  days of feeding)  $\times$  100; Feed efficiency = fish weight gain / feed consumed.

# 結果

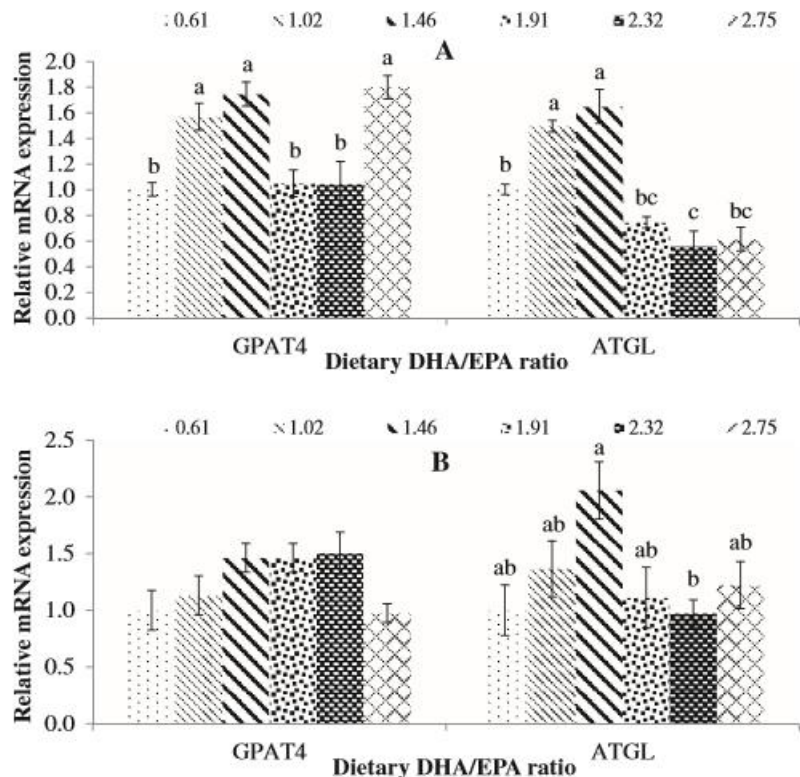


**Fig. 2.** Effects of dietary DHA/EPA ratio on the mRNA expressions of lipogenic proteins in the liver (A) and muscle (B) of tongue sole. Values (means  $\pm$  standard error,  $n = 3$ ) in bars that do not have the same letter are significantly different ( $P < 0.05$ ). ACC: acetyl-CoA carboxylase; FAS: fatty acid synthetase; PPARα1: peroxisome proliferator-activated receptor α1; SREBP1: sterol regulatory element-binding protein 1.



**Fig. 3.** Effects of dietary DHA/EPA ratio on the mRNA expressions of  $\beta$ -oxidation-related proteins in the liver (A) and muscle (B) of tongue sole. Values (means  $\pm$  standard error,  $n = 3$ ) in bars that do not have the same letter are significantly different ( $P < 0.05$ ). ACO3: Aco-CoA oxidase 3; CPT-1 $\alpha$ : carnitine palmitoyl transferase-1 $\alpha$ ; PPAR: peroxisome proliferator-activated receptor.

## 结果



**Fig. 4.** Effects of dietary DHA/EPA ratio on the mRNA expressions of triglyceride metabolism-related proteins in the liver (A) and muscle (B) of tongue sole. Values (means  $\pm$  standard error,  $n = 3$ ) in bars that do not have the same letter are significantly different ( $P < 0.05$ ). GPAT4: glycerol-3-phosphate acyltransferase 4; ATGL: adipose triglyceride lipase.

与低(0.61)或高相比(2.32-2.75) DHA/EPA比值相比，DHA/EPA比值(1.02-1.46)饲料养殖半滑舌鲷脂质积累增高。生长结果表明，饮食适度DHA/EPA比值也会导致脂质积累在增重和饲料利用率方面有更好的生长性能。



河南师范大学

NENAN NORMAL UNIVERSITY

# THANKS

---

敬请各位老师同学批评指正

---