**Supplementary data**

Table 1. Ingredients and proximate nutrient composition of the basal diet (% dry matter)

|  |  |
| --- | --- |
| Ingredients | Content (%) |
| White fish meal1 | 43.0 |
| Shrimp head meal | 3.0 |
| Soybean meal | 16.88 |
| Vital Wheat Gluten | 7.00 |
| Fish oil2 | 2.5 |
| Soybean oil | 2.5 |
| Lecithin | 2.0 |
| Wheat meal | 20.0 |
| Choline chloride3 | 0.5 |
| Vitamin premix4 | 0.5 |
| Mineral premix5 | 0.5 |
| Ca(H2PO4)2 | 1.5 |
| Antifungal agent | 0.10 |
| Antioxidant | 0.02 |
| *Proximate nutrients composition* |  |
| Crude protein | 45.85 |
| Crude fat | 12.16 |
| Crude ash | 9.82 |

1White fish meal was obtained from Jiakang Feed Co. Ltd., Xiamen, China, imported from Peru (crude protein 68.34%, crude lipid 9.06%).

2Fish oil were obtained from Jiakang Feed Co. Ltd., Xiamen, China.

3Cholesterol was produced by Baiwei Biotechnology Holdings Co., Ltd, Hebei, China, which is extracted from pig, cattle or sheep brain and the minimum level is higher than 95%.

4Vitamin premix (mg kg-1 diet): vitamin A, 15; vitamin D3, 15; vitamin E, 75; vitamin K3, 50; vitamin B1, 50; vitamin B2, 75; vitamin B6, 75; vitamin B12, 0.3; nicotinic acid, 200; inositol, 350; *D*-calcium pantothenate, 200; folic acid, 9; *D*-biotin, 0.5.

5Mineral premix (mg kg-1 diet): FeSO4·7H2O, 278; CuSO4·5H2O, 41; ZnSO4·7H2O, 463; MnSO4·4H2O, 57; MgSO4·7H2O, 2009; CoSO4·7H2O, 3; Na2SeO3 0.6, Ca (IO3)2, 5.

Table S2MetaStat analysis of the abundance of intestinal bacterial phylaand genera (×10-4)at day 56

|  |  |
| --- | --- |
|  | Groups |
|  | T1 | T2 | T3 | T4 |
| **Phylum** |  |  |  |  |
| Proteobacteria | 4725.33±1619.45 | 4304.86±1427.91 | 3839.85±1505.65 | 3421.06±864.67 |
| Firmicutes | 1935.71±668.07 | 2383.81±974.68 | 1997.79±1193.42 | 3710.44±701.56 |
| Bacteroidetes | 1111.80±33.49 | 986.53±428.77 | 1524.32±708.22 | 1241.53±379.39 |
| Actinobacteria | 1408.23±436.17ab | 1683.84±125.45a | 741.37±234.00 b | 666.18±233.99 b |
| Cyanobacteria | 398.92±121.21 | 127.93±35.61 | 239.10±17.99 | 190.55±93.91 |
| **Genus** |  |  |  |  |
| *Photobacterium* | 2757.05±2186.63 | 1327.94±1196.06 | 2670.23±1671.78 | 1461.168±1000.98 |
| *Rhodococcus* | 968.05±301.78 | 899.42±272.79 | 505.62±169.57 | 404.58±143.29 |
| *uncultured\_bacterium* | 405.26±122.89 | 129.25±35.56 | 1528.32±882.73 | 172.76±84.48 |
| *Catenococcus* | 431.53±327.84 | 1438.40±1432.80 | 123.64±60.57 | 48.90±21.80 |
| *Vibrio* | 300.17±129.35 | 686.11±419.02 | 213.16±123.97 | 617.85±388.75 |
| *Lactobacillus* | 148.67±48.25 | 226.18±110.79 | 137.48±114.00 | 1105.22±1018.37 |
| *Brevinema* | 418.21±413.85 | 581.60±553.71 | 143.27±112.93 | 274.30±270.97 |
| *Bacteroides* | 334.47±125.89 | 313.27±142.17 | 428.96±305.96 | 242.28±64.81 |
| *uncultured\_bacterium\_f\_Muribaculaceae* | 85.34±38.89 | 161.50±87.23 | 136.90±107.11 | 385.84±185.11 |
| *Lachnospiraceae\_NK4A136\_group* | 134.87±53.49 | 156.58±65.33 | 84.15±43.22 | 384.77±285.53 |