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Effects of different dietary oil sources on growth performance, antioxidant capacity and lipid deposition of juvenile golden pompano *Trachinotus ovatus*

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Abstract

Vegetable oils (VO) that are used to substitute fish oil in aquafeeds may affect, not only the fatty acid composition, but also lipid metabolism and distribution. The present study was designed to investigate this issue in juvenile golden pompano *Trachinotus ovatus* fed eight diets formulated with typical VO with widely varying fatty acid compositions including coconut oil (CO), palm oil (PO), oil-tea camellia seed oil (OTO), olive oil (OO), canola oil (CNO), peanut oil (PNO), linseed oil (LO) and perilla oil (PFO), in comparison with fish fed fish oil (FO). After the 8-week feeding trial, fish fed the CO diet had the highest growth performance, and higher general antioxidant capacities in serum and liver than in fish fed the other VO. The crude lipid content in whole body and expression levels of *fas* were lower in fish fed the FO, PFO and LO diets, while lipid contents and expression levels of *scd* were higher in fish fed the OTO and PNO diets. Other than fish fed the PFO diet, the total lipid contents of liver in other fish fed the other VO diets were higher than that in fish fed the FO diet, with the highest contents in fish fed the OTO and OO diets. The expression levels of genes involved in fatty acid catabolism and transport, namely *pparα*, *cpt1* and *apoB100*, were higher in fish fed diet PFO than in fish fed the other diets. Comparing the fatty acid compositions of tissues and diets showed that 18:1n-9, 18:3n-3 (ALA) and 22:6n-3 (DHA) were preferentially deposited in tissues of pompano, with DHA preferentially deposited in polar lipids rather than neutral lipids. However, excessive dietary ALA in PFO did not lead to increased deposition of ALA, but increased liver lipid content. The present study showed that dietary lipid sources had significant influences on growth performance and antioxidant capacity, as well as on lipid deposition. Low dietary 18:1n-9, high n-3 long-chain polyunsaturated fatty acids and an appropriate ratio of ALA/LNA (18:2n-6) could reduce lipid deposition in pompano tissues, especially liver.

Keywords: *Trachinotus ovatus*, lipid sources, vegetable oils, growth performance, lipid deposition

1 Introduction

In recent decades, the farming of aquatic organisms has been the fastest growing animal protein and food producing sector, supplying over 50 % of global fish and seafood for human consumption (Sprague *et al*., 2017). In consequence, the design and manufacture of aquafeeds for marine animal species will continue to be a key cornerstone in the future development of sustainable fish farming. Fish oil has been a traditional and popular raw material for the supply of dietary lipids in aquafeeds, providing excellent nutritional value (Sun *et al*., 2011). In particular, fish oil is rich in n-3 long-chain polyunsaturated fatty acid (n-3 LC-PUFA) including eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), which are essential nutrients with important roles in many physiological and biochemical processes, including immune and anti-inflammatory responses, and nervous system development among others (Firat *et al*., 2017; Li *et al*., 2020a). However, on an annual basis, fish oil is a finite natural resource and its supply has reached its sustainable limit, and so increasing demand has resulted in prices rising year on year (Turchini *et al*., 2011a). Therefore, finding sources of appropriate oils to replace dietary fish oil has been a subject of considerable research interest for many years (Turchini *et al*., 2009, 2011b). The research results have encouraged the global aquaculture industry to consider a spectrum of potential lipid sources as alternatives to marine oils, with increasing proportions of fish oil being replaced by alternative oils resulting in increased sustainability and economic viability of fish farming (Ytrestøyl *et al*., 2015; Aas *et al*., 2019).

The main alternatives to fish oil that have been extensively evaluated in various fish species in recent years are vegetable oils (VO) that, although being devoid of the n-3 LC-PUFA, EPA and DHA, can offer a wide range of different fatty acid compositions. Among others, potential alternative VO include coconut oil, palm oil, canola, olive oil, camellia (tea) seed oil, peanut oil, linseed oil and perilla oil. Coconut oil, enriched in up to 45 % lauric acid (12:0), has shown potential to stimulate growth and health of some fish species, such as yellow catfish *Pelteobagrus fulvidraco* (Lu *et*

al., 2018). Palm oil, the second largest edible oil in the world by volume with a lower price than other VO, is enriched in palmitic acid (16:0) and can replace dietary fish oil in some fish species with no negative impacts on growth performance or feed utilization (Naing *et al*., 2007). Both olive and camellia seed oils are enriched in oleic acid (18:1n-9) up to almost 80 %, and have similar physicochemical properties that are highly suitable for use in aquafeeds (Preedy *et al*., 2011). Although generally no negative impacts on growth of fish fed olive oil or camellia seed oil were observed, liver lipid contents were increased in some fish species, such as yellowtail *Seriola quinqueradiata* (Seno *et al*., 2008) and hybrid tilapia *Oreochromis niloticus* × *O. aureus* (Han *et al*., 2012). Canola (or rapeseed) oil contains not only a high content of 18:1n-9 but also abundant linoleic acid (LNA, 18:2n-6) along with other minor lipid compounds such as phytosterols and tocopherols, and also affects lipid metabolism in fish (Pettersson *et al*., 2010). Peanut oil, also rich in 18:1n-9 and LNA, has been used to replace fish oil without obvious impacts on growth performance in several species of fish, including juvenile African catfish *Clarias gariepinus* (Zaid and Akinremi, 2009), Mozambique tilapia *O. mossambicus* (Demir *et al*., 2014) and two-banded seabream *Diplodus vulgaris* (Osman *et al*., 2016). Linseed oil and perilla oil, which contain abundant α-linolenic acid (ALA, 18:3n-3), have been regarded as functional lipid sources, having the ability to modulate lipid metabolism in Atlantic salmon (*Salmo salar*) (Bell *et al.*, 2003; Bell *et al.*, 2004) and South American catfish *Jundiá* (Rodrigo *et al*., 2008). Compared to other VO, linseed and perilla oils had positive effects on n-3 PUFA deposition in Nile tilapia *O. niloticus* (Dos *et al*., 2014), rainbow trout *Oncorhynchus mykiss* (Wijekoon *et al*., 2014) and Japanese seabass *Lateolabrax japonicus* (Xu *et al*., 2015), contributing to increased nutritional value.

In terms of fatty acid composition, the VO can be classified into four groups, depending upon whether they are enriched in saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), n-6 PUFA or n-3 PUFA. Studies have shown that diets rich in the different fatty acid groups can have differential effects on the fatty acid compositions of different tissues (liver and muscle) and, in some cases, can significantly affect fish fillet quality and health (Martínez-Lorens *et al*., 2007; Menoyo

et al., 2004; Mourente *et al*., 2005). However, whether VO containing similar fatty acid groups/compositions have entirely similar effects on growth performance and lipid metabolism including deposition in different tissues, particularly liver and flesh, requires further research.

The golden pompano, *Trachinotus ovatus*, belongs to the *Carangidea* family, and is a euryhaline species able to thrive in both seawater and brackish water (Tutman *et al*., 2004). It is highly regarded by consumers who appreciate its delicious, delicate taste and the fact its fillet has few small bones. In addition, golden pompano displays rapid growth and is easy to handle and, therefore, is a highly farmed fish in south-eastern China with important economic value (Tan *et al*., 2017). Golden pompano is omnivorous but with a carnivorous tendency and has been the subject of considerable research into various aspects of culture including nutrient requirements (Tang *et al*., 2013) such as optimum levels of dietary protein (Ma *et al*., 2014) and lipid (Wang *et al*., 2013; Li *et al*., 2020b), dietary additives (Zhou *et al*., 2015), stocking density and stress. In addition, high PUFA contents in muscle make golden pompano an interesting species in which to investigate the impacts of different dietary VO in marine fish (Sun *et al*., 2018). One study showed that pompano fed dietary soybean and corn oils (both rich in LNA and to a lesser extent 18:1n-9) showed significantly lower specific growth rate and muscle lipid content than fish fed a diet with fish oil (Li *et al*., 2019). Another study reported that fish fed soybean oil or lard showed increased lipid content of whole body, liver and muscle (Liu *et al*., 2018). These contradictory results suggest that little is known about the effects of dietary lipid substitution and, particularly, their impacts on lipid metabolism and tissue fat deposition in golden pompano.

The aims of the present study were to evaluate the effects on growth performance, tissue fat distribution and lipid oxidation resistance in golden pompano fed eight VO with a range of fatty acid compositions, in comparison with fish fed a fish oil diet as the control, in order to determine appropriate lipid sources as alternatives to dietary fish oil. The results of the study provide reference data and a theoretical basis for the formulation of feeds with fatty acid compositions balanced to promote the health of

marine fish.

2 Materials and methods

2.1 Experimental diets

Nine isoproteic (~45.7 % crude protein) and isolipidic (~12.5 % total lipid) experimental diets were formulated to contain different lipid sources, specifically coconut oil (CO), palm oil (PO), oil-tea camellia seed oil (OTO), olive oil (OO), canola oil (CNO), peanut oil (PNO), linseed oil (LO) and *Perilla frutescens* seed oil (PFO) with a fish oil diet (FO) as a control. The dietary ingredients, proximate compositions and fatty acid compositions are detailed in Table 1. All dry ingredients were ground into fine powder, and micro components such as mineral and vitamin premixes added followed by lipid and distilled water (20 %, w/w). Ingredients were blended thoroughly by hand, before pellets (4 mm and 5 mm diameter) were produced using an automatic pelleting machine (SLC-45, Fishery Machinery and Instrument Research Institute, China). Pellets were air-dried to approximately 10 % moisture, after which the diets were stored at −20 °C until use.

2.2 Experimental fish and feeding procedure

The feeding trial with golden pompano *T. ovatus* was conducted at the Nan Ao Marine Biology Station (NAMBS) of Shantou University, Southern China. A total of 810 juvenile pompano were obtained from a local commercial farm in Zhangzhou, Fujian, China and fed a mixture of equal proportions of all nine experimental diets for two weeks to acclimatize to the experimental conditions. At the end of this period, fish were fasted for 24 h and weighed after being anesthetized with 0.01 % 2–phenoxyethanol (Sigma–Aldrich, USA). Fish (initial weight 10.6 ± 0.2 g) were randomly distributed into 27 floating net cages (1.0 m × 1.0 m × 1.5 m), with 30 fish per cage and 3 cages per diet. Twice a day (6:30 and 17:00), the fish in each cage were hand-fed carefully to ensure feeding to obvious satiation and the feeding trial lasted for

8 weeks. Mortalities were collected, recorded and weighed throughout the trial. The sea water temperature was 10.5 – 20.0 °C, salinity was 33 - 35 ppt and dissolved oxygen was 7 $mg \cdot L^{-1}$.

2.3 Sample collection

At the end of the feeding trial, fish were fasted for 24 h prior to sample collection. All fish in every net gage were anaesthetized with 0.01 % 2–phenoxyethanol (Sigma–Aldrich, USA), counted and weighed individually. Anaesthetized fish were euthanized by a blow to the head prior to collection of the appropriate fish and tissue samples. Three fish were randomly collected from each net cage and stored at -20°C for whole body composition analysis. A sample of blood was collected by heparinized syringe from the caudal vasculature of 3 fish randomly collected per net cage and held at 4 °C for 6 h prior to centrifugation (4000 g, 10 min). The serum obtained was stored at -20 °C in 2 mL sterile tubes (Axygen, USA) until used for the measurement of biochemical and antioxidant indices. Samples of liver, dorsal muscle, and abdominal muscle were collected in 2 mL sterile tubes (Axygen) from another 3 fish per net gage and stored at -80 °C prior to lipid and fatty acid analyses. A further sample of liver was collected from these fish and snap frozen for analysis of genes involved in lipid and fatty acid metabolism. Liver and whole viscera of all sampled and dissected fish were weighed for determining hepatosomatic (HSI) and viscerosomatic (VSI) indices.

2.4 Proximate and fatty acid compositions

The proximate compositions (protein, lipid, ash and moisture contents) of diets and whole fish were determined according to standard methods (AOAC, 2006). For fatty acid analysis, total lipid was extracted from samples of diets, liver, dorsal muscle and ventral muscle by extracting with chloroform / methanol (2:1, v/v) containing 0.01 % butylated hydroxytoluene (BHT) as antioxidant according to the method of Folch *et al*. (1957). Total lipids of fish tissues were fractionated into total neutral and polar lipids by chromatography using Sep-Pak$^{@}$ Vac 6cc (500 mg) silica cartridges (Waters,

Ireland). Neutral lipids were eluted with chloroform (30 mL) and polar lipids with methanol (30 mL) as described by Belaunzaran *et al*. (2017), and fatty acid methyl esters of these fractions were prepared as follows. Lipids were saponified with 0.5 M potassium hydroxide in methanol before transesterification with boron trifluoride methanol (ca. 14 %; Acros Organics, NJ, USA). Fatty acid methyl esters were separated by gas chromatography (GC-2010 plus; Shimadzu, Kyoto, Japan) equipped with an auto-sampler and a hydrogen flame ionization detector as described in detail previously (Li *et al*., 2010). Individual fatty acids were identified by comparison with known commercial standards (Sigma-Aldrich, St. Louis, MO, USA) and quantified with GC-solution workstation (Shimadzu, Kyoto, Japan).

2.5 Serum biochemical indices

Serum samples were assayed within 24 h after collection and storage at 4°C. Contents of total protein (TP), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglyceride (TG), total-cholesterol (T-CHO) and non-esterified fatty acid (NEFA), and activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined using commercial assay kits (Nanjing Jiancheng Bioengineering Institute, China). All the enzymatic activities and nonenzymatic factor contents were calculated according to the manufacturer's instructions.

2.6 Antioxidant indices in serum and liver

Serum samples were assayed within 24 h of collection after storage at 4 °C. Hepatic samples were homogenized in ice-cold physiological saline 0.89 % (w/v) buffer, and the homogenate centrifuged for 20 min at 800 g to collect the supernatant. The content of malondialdehyde (MDA) in serum and liver supernatants was determined using assay kits (Nanjing Jiancheng Bioengineering Institute, China). The activities of serum and liver glutathione peroxidase (GSH-PX), catalase (CAT), superoxide dismutase (SOD), and total antioxidant capacity (T-AOC) were determined

using commercial assay kits (Nanjing Jiancheng Bioengineering Institute). All the enzymatic activities and nonenzymatic factors were calculated according to the manufacturer's instructions.

2.7 Real time quantitative PCR

Total RNA from liver was isolated using RNAprep pure Tissue Kit® (Tiangen, China) according to the manufacturer's instructions. The RNA quality was assessed by formaldehyde agarose gel electrophoresis, and the concentration of RNA was quantified by A260/A280 ratio (between 1.8 and 2.0) by spectrophotometry (NanoDrop 2000, Thermo Fisher, Germany). The reverse transcriptase reaction was performed using a FastQuant® RT kit (Tiangen) including a genomic DNA elimination reaction. Quantitative real time PCR (qPCR) was carried out on a LightCycler® 480 thermocycler (Roche, Germany) in a total volume of 20 μL with 10 μL SYBR Green I Master (Roche), 7 μL ddH_2O, 1 μL of each primer (10 μM), and 1 μL of diluted cDNA (200 ng μL^{-1}). The qPCR program followed the manufacturer's protocol and all amplification reactions were run in triplicate. The specificity and efficiency of the primers for the β-actin (reference gene) and target genes were determined by constructing a standard curve using serial dilutions of cDNA. The expression levels of the target genes were calculated using the $2^{-\Delta\Delta Ct}$ method with fish fed the control diet (FO) used as the reference group. The specific primers of the reference and target genes were as follows: β -actin, sense TACGAGCTGCCTGACGGACA and antisense GGCTGTGATCTCCTTCTGC; fatty acid synthase (*fas*), sense GAAGGAGAGGGGGTGGAGTC and antisense GTGTGAAGGTGGAGGGTGTG; stearoyl-CoA desaturase (*scd*), sense CCTTTTACGGCGTGTTCG and antisense TGGGGTTGATGTTCTTGT; peroxisome proliferator-activated receptor alpha (*pparα*), sense AATCTCAGCGTGTCGTCTT and antisense GGAAATGCTTCGGATACTTG; carnitine palmitoyltransferase I (*cpt1*), sense CTTTAGCCAAGCCCTTCATC and antisense CACGGTTACCTGTTCCCTCT;

apolipoprotein B100 (*apoB100*), sense AAAAGCCACAAGACGAAAGCA and antisense GAAGCAGCAAAAGGCAGAGC.

2.8 Calculations and statistical analysis

Data were presented as means ± S.E. (n value as indicated). All data were subjected to one-way analysis of variance (ANOVA), and comparisons among the treatments were determined by Tukey's multiple range test at the $P < 0.05$ level of significance using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA).

3 Results

3.1 Growth performance and feed efficiency

The growth performance and feed efficiency of juvenile pompano *T. ovatus* fed the experimental diets are shown in Table 2. Neither survival rate (SR) nor feed conversion ratio (FCR) showed any statistical differences among the dietary treatments. Of the fish fed the VO diets, only fish fed diets CO and PFO showed slightly better growth performance values than fish fed the FO diet, with numerically higher final weights, weight gain (WG) and specific growth rate (SGR), although the data were not statistically significant. Within the VO diets, fish fed the CO and PFO diets had significantly better growth performance with higher final weights, WG and SGR than fish fed diet PO. Fish fed the CO diet had significantly higher VSI than fish fed the FO diet, while fish fed both CO and PO diets had significantly higher HSI than fish fed FO. Fish fed the OTO diet also had significantly higher condition factor (CF) than fish fed FO.

3.2 Proximate composition of whole body

The proximate compositions of whole body of juvenile pompano fed the experimental diets are shown in Table 3. Fish fed the PO diet had a lower protein content than fish fed the FO diet and all other diets except diet CO. The highest levels

of total lipid were found in pompano fed the OTO and PNO diets, which were significantly higher than fish fed the control FO diet and diet PFO. Ash content in pompano fed the CNO diet was significantly higher than in fish fed the CO, OTO and LO diets. Moisture contents did not show any significant differences among the experimental groups.

3.3 Biochemistry indexes in serum

As shown in Table 4, HDL tended to be higher, and LDL lower, in fish fed the FO diet compared to fish fed the VO diets, but this was generally not statistically significant other than LDL being significantly higher in fish fed the OTO and OO diets compared to fish fed all other diets. Serum concentrations of TG and T-CHO did not show any statistical differences among the dietary treatments, but pompano fed the CO and PO diets had significantly lower NEFA concentration than fish fed the other diets. Pompano fed the LO diet had significantly higher serum ALT activity than fish fed all the other diets, and lower AST activity than fish fed the other diets, significantly so in the case of fish fed the OTO, OO and PO diets.

3.4 Antioxidation parameter in serum and liver

Antioxidation parameters in serum and liver of juvenile pompano fed the experimental diets are shown in Table 5. Serum MDA level in fish fed the PNO diet was significantly lower than in fish fed diets PO, FO and LO, while liver MDA levels were generally higher in fish fed the PO and LO diets. The GSH-PX activity showed similar trends in serum and liver, with fish fed the VO diets, other than diet CO, having significantly lower activity than fish fed the FO diet. The significantly lowest activity of CAT in serum was observed in fish fed diet PO and, in liver, CAT activity was also lowest in fish fed diet PO, significantly so in fish fed the FO, CO, PNO and PFO diets. Compared with fish fed the FO diet, SOD activity in serum was lower in fish fed the PNO diet, while SOD activity in liver was generally higher in fish fed the CO and OTO diets, and lower in fish fed the OO diet. In serum, pompano fed the FO, CO and PFO

diets had significantly higher T-AOC activity than fish fed the PNO diet, while fish fed diet PNO had significantly higher T-AOC activity in liver than fish fed the OO diet.

3.5 Total lipid contents of tissues

Irrespective of diet, lipid content was highest in the liver, and lowest in dorsal muscle, with ventral muscle showing intermediate levels, and diet had differential effects on the distribution of lipid in the different tissues considered (Fig. 1). Liver lipid contents were significantly higher in fish fed all the VO diets, other than diet PNO, with highest lipid contents in fish fed the OTO, OO and PFO diets. Diet had less impact on lipid content of dorsal muscle with only fish fed the OTO and OO diets showing higher lipid contents than fish fed the control FO diet. In general, the VO diets reduced the lipid content of ventral muscle compared to fish fed the control FO diet, with fish fed the CO, PO and CNO diets showing significantly lower lipid contents than fish fed the other diets. The contents of neutral lipid (NL) and polar lipid (PL) showed the same trend as total lipids in fish fed all the diets (Table 6). The ratio of NL/PL was not significantly affected by diet but, overall, it was higher in the muscle than in the liver, other than in fish fed the LO diet.

3.6 Fatty acid composition of neutral or polar lipid in liver, dorsal muscle and ventral muscle

The fatty acid compositions of NL in liver, dorsal muscle and ventral muscle are shown in Fig. 2 (detailed in supplementary table 1, 2 and 3), and the fatty acid compositions of PL are shown in Fig. 3 (detailed in supplementary table 4, 5 and 6). The results showed that the specific fatty acid compositions of the different dietary oil sources were reflected in both the NL and PL fatty acid compositions of the tissues, but that the fatty acid compositions differed between the tissues. In particular, liver fatty acid compositions were different to those of dorsal and ventral muscles that had generally similar fatty acid compositions. However, the LC-PUFA, especially DHA,

were preferentially deposited/retained in PL rather than NL in all tissues (Figs. 2 and 3, detailed in supplementary table 1, 2, 3, 4, 5 and 6).

3.7 The expression of lipid metabolism-related genes in liver

As shown in Fig. 4, the expression level of *fas* in liver was not significantly different in pompano fed the VO diets when compared to fish fed the FO diet. However, fish fed the OTO, OO and PNO diets had significantly higher *fas* expression level than fish fed the LO and PFO diets, while pompano fed the CO and PO diets had significantly higher *scd* expression level than fish fed the OO and PNO diets. The *apoB100*, *cpt1* and *pparα* gene expression levels showed similar trends, with fish fed the control FO diet showing generally low levels, and fish fed the PNO diet showing higher levels than fish fed all the other diets other than fish fed diet LO in which *apoB100* was similarly high.

4 Discussion

The present study has shown that dietary oil sources with different fatty acid compositions, as alternatives to fish oil, had specific impacts on growth performance in juvenile pompano *T. ovatus*. Our results on growth parameters and feed efficiency, which generally resulted in good performance of the VO in comparison to fish oil, suggested that juvenile pompano can efficiently use a variety of dietary VO sources to replace fish oil. It is interesting to note that, among the different types of VO tested, diets formulated with SFA-rich oils, namely CO (coconut oil is rich in 12:0) and PO (palm oil is rich in 16:0), had a remarkably different impact on fish growth, with CO fish having significantly higher SGR and WG compared to the PO diet fed fish. While previous studies have reported that palm oil's digestibility can be low in some fish (Turchini *et al.*, 2009), and that pompano and other marine species efficiently utilize dietary coconut oil (oil source of CO diet) (Luo *et al*., 2014; Henderson, 1996), it is challenging to explain the growth results attending exclusively to the fatty acid composition. Rather, our analyses on MDA, a marker reflecting the degree of lipid

peroxidation in the body and indirectly reflect the amount of cell damage (Peng *et al.*, 2008), confirmed high concentrations in serum and liver suggesting increased peroxidation damage in pompano fed the PO diet, which could ultimately compromise growth performance in this experimental group. In agreement, compared to PO fish, both serum and liver of juvenile pompano fed the CO diet had high activities of SOD, CAT, GSH-PX and T-AOC, well-known antioxidant components that scavenge free radicals and reduce oxidative damage in fish (Sun *et al*., 2011). This may be explained by the fact that the coconut oil in the CO diet was produced by cold-pressing, a process that can preserve nutritional qualities by protecting minor components such as polyphenols (Kapilan, 2008), compounds with the ability to enhance the activity of antioxidant enzymes and eliminate excess free radicals in cells (Nevin *et al*., 2004, 2009). Unlike CO diet, relatively low activity levels of SOD, CAT and GSH-PX in pompano fed the PO diet may result in greater oxidative damage that suppressed growth of fish associated to impaired liver metabolism (Huang *et al*., 2008).

Many previous studies have shown that different dietary oil sources significantly affected whole body lipid contents of marine fish (Olsen *et al*., 2007). Consistently, juvenile pompano fed the FO, PFO and LO diets in this study had the lowest levels of total lipid in whole body. These were the diets particularly enriched in n-3 PUFA or LC-PUFA, suggesting that dietary n-3 fatty acids had the potential to reduce total fat accumulation in body of juvenile pompano. In addition to whole body lipid composition, we also investigated the lipid content of particular tissues including liver, dorsal muscle and ventral muscle, since it is well known that the impact of different dietary oil sources on the precise distribution of lipid/fat in these tissues can have very important practical significance associated to product quality and fish health. In agreement with previous studies, juvenile pompano fed diets formulated with VO other than peanut oil (PNO diet) as substitutes for fish oil increased the lipid content of liver (e.g., Jordal *et al*., 2007; Menoyo *et al*., 2004). Often, such trend is also observed in muscle and thus dietary VO such as rapeseed, palm, linseed and olive oils also increased the lipid content in muscle of Atlantic salmon (Torstensen *et al*., 2011) and gilthead sea bream (Cruz-Garcia *et al*., 2011). However, in contrast, other studies suggested that the lipid

content of liver, muscle and ventral adipose tissues were reduced by feeding VO including rapeseed, palm and linseed oils in Atlantic salmon (Nanton *et al*., 2007; Bell *et al*., 2001).

In agreement with previous reports (see Turchini *et al*., 2011b), the fatty acid composition of the dietary VO used in the present study mostly determined that of the fish tissues. However, our analyses revealed that pompano do not merely accumulate dietary fatty acids but rather metabolize actively some of them. Thus, it was interesting to note that the levels of 18:1n-9 in tissues were higher than in the diets other than in fish fed the OO and OTO diets, which had high concentrations of 18:1n-9. Since pompano, as any other teleost (Monroig *et al*., 2018), can convert 18:0, 16:0 or short-chain SFA to 18:1n-9, such fatty acids and energy are consumed when 18:1n-9 was low in the diet. Perhaps as a result, the lipid content was highest in liver of pompano fed the OO and OTO diets. Similar results had been reported in Atlantic salmon (Torstensen *et al.*, 2004) and yellowtail (Seno *et al*., 2008). Thus, diets like OO and OTO, enriched in MUFA, particularly 18:1n-9, have been shown to promote lipid accumulation in tissues of fish (Du *et al*., 2008). The results of gene expression also support this hypothesis, as mRNA levels of *scd*, the gene encoding the stearoyl-CoA desaturase responsible for 18:1n-9 biosynthesis from 18:0 (Monroig *et al*., 2018), were lower in fish fed the OO and OTO diets, and correspondingly higher in fish fed the CO and PO diets. However, the expression of *fas*, encoding the fatty acid synthase complex responsible for 16:0 and 18:0 biosynthesis, did not increase significantly in fish fed the CO and PO diets.

The feeding trial further showed that pompano preferentially deposits DHA in polar lipids as suggested by the fact that, in addition to the FO group, the other dietary groups also maintained high levels of DHA in the liver and muscle. As many other marine fish, it is likely that pompano cannot convert ALA to DHA, so maintaining DHA levels may require depositing more lipid in tissues. Except for fish fed diets PNO, CO and LO, the total lipid content of liver in fish fed the other VO was higher than that in FO group. This is consistent with the results of many studies (Tocher, 2015), and may suggest a further underlying mechanism. Interestingly, pompano fed the diets enriched in SFA and, to a lesser extent, MUFA, had higher DHA contents in tissue polar lipids

than fish fed the other diets, while fish fed diets enriched in n-3 PUFA and n-6 PUFA showed lower levels of DHA in polar lipid. This phenomenon has been explained by the fact that high dietary MUFA and SFA can reduce the catabolism of n-3 LC-PUFA (Turchini *et al*., 2011a). Another interesting result in the present study was that the ratio of DHA to EPA was much higher in polar and neutral lipids than in the feeds, which suggested that pompano actively converted EPA to DHA. Our previous studies have shown that pompano has the capability to convert EPA to DHA, despite the lack of a complete pathway for the biosynthesis of LC-PUFA (Wang *et al*., 2020; Zhang *et al*., 2019). Similar results were reported in tilapia, where fish fed fish oil-free diets maintained high DHA/EPA ratios in both polar and neutral lipid (Liu *et al*., 2019).

In the present trial, the PNO diet with high dietary LNA, increased whole body lipid content, but decreased liver lipid content in pompano. Consistent with this, previous studies reported that feeding peanut oil (as in the PNO diet) increased muscle lipid and reduced liver lipid contents in freshwater fish including rainbow trout (Acar and Türker, 2018) and goldfish *Carassius auratus* gibelio (Wang *et al*., 2010). Another previous study showed that high dietary LNA significantly increased the expression of *pparα* in Wuchang bream *Megalobrama amblycephala* (Li *et al*., 2015). The present study showed that the highest levels of *pparα* and *cpt1* mRNA were found in fish fed the PNO diet with highest LNA. Both *pparα* and *cpt1* are genes with important roles in the regulation of β-oxidation and, thus, in the process of fatty acid catabolism (Stubhaug *et al.*, 2005ab; Kersten *et al.*, 2000), suggesting that the high dietary LNA content could promote fatty acid catabolism, thereby reducing lipid content in the liver of fish fed diet PNO. Furthermore, the mRNA level of *apoB100* was also higher in fish fed the PNO diet. *ApoB100* is an indispensable component of very low-density lipoprotein (VLDL) (Pan *et al.*, 2008), and LNA was reported to significantly increase *apoB100* secretion in mammalian liver cells (López-Soldado *et al*., 2009). As VLDL is the main route for lipid export from the liver, increased *apoB100* expression can also help reduce the lipid content in liver.

The ratio of ALA to LNA is another factor that may affect tissue lipid deposition. In the present study, other than diets LO and PFO, the content of ALA was low in the

VO diets, but the level of ALA in pompano tissues was higher than the levels in these diets. In contrast, the levels of ALA deposited in the tissues of pompano fed the LO and PFO diets was lower than the levels in the diets. Indeed, the total lipid content of pompano appeared most closely to be related to the ALA to LNA ratio. The rank order for this ratio in the VO feeds was PFO > LO > CO > OO=CNO >OTO >PO > PNO, while the rank order for whole body lipid content was PNO > OTO > CO > OO > CNO > PO > LO > PFO. Therefore, the diets with the highest ALA/LNA ratio (PFO and LO) resulted in the lowest body lipid contents while the diet with the lowest ALA/LNA ratio PNO) gave the highest body lipid content. This association between body lipid content and dietary ALA/LNA ratio was stronger than the associations between body lipid content and the individual fatty acids, ALA and LNA. The rank order for ALA in the feeds was PFO > LO > CNO > OTO = PNO > PO > OO > CO, and for LNA it was PNO > LO > CNO > PO > PFO > OTO > OO > CO. Similarly, total SAFA and MUFA in feeds did not show as strong an association as ALA/LNA ratio with whole body lipid content.

In conclusion, of the VO tested, fish fed the CO diet showed the best growth performance and better antioxidant capability of juvenile golden pompano *T. ovatus*. The excessive accumulation of lipid in fish caused by dietary VO may be related to the balance of dietary fatty acids, especially the ALA/LNA ratio. When the diet lacks essential fatty acid, such as DHA, the fish may retain more lipid in order to maintain the level of this fatty acid. Dietary peanut oil significantly increased the expression of genes related to fatty acid catabolism and transport, which may be related to the high content of LNA. In summary, the present study confirmed the effects of various lipid sources of VO on the growth performance, antioxidant capability and lipid deposition in *T. ovatus*. Furthermore, the results provided the basis for further studies on the underpinning molecular mechanisms, as well as key information for developing precise feeds with balanced dietary fatty acid compositions that will be particularly beneficial for marine species to promote the production of healthy farmed fish.

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Table 1. Ingredients (%), proximate compositions and fatty acid composition (% total fatty acids) of experimental diets (% dry matter).

Ingredients (%)	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
Fish oil	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coconut oil	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palm oil	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil-tea oil	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00
Olive oil	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00
Canola oil	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00
Peanut oil	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00
Linseed oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00
Perilla seed oil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00
Others[1]	93.00	93.00	93.00	93.00	93.00	93.00	93.00	93.00	93.00
Proximate composition (% dry weight)									
Moisture	9.44	9.75	9.75	9.44	11.17	12.95	11.62	10.64	9.76
Crude protein	45.48	46.04	45.62	46.54	45.47	45.37	45.31	45.43	46.17
Crude lipid	12.57	12.54	12.86	12.49	11.96	12.60	12.12	12.39	12.56
Ash	8.49	8.91	9.11	8.52	8.67	8.73	8.75	8.60	8.64
Fatty acid composition (% total fatty acids)									
C10:0	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C12:0	0.00	33.79	1.70	0.06	0.00	0.00	0.00	0.00	0.00
C14:0	5.78	13.99	3.12	1.65	1.24	1.29	1.66	1.35	1.51
C16:0	19.88	11.61	32.03	13.13	14.72	10.32	12.95	10.32	9.40
C16:1n-9	5.62	1.48	1.67	1.64	1.47	1.36	1.47	1.32	1.34
C18:0	3.74	3.08	2.59	2.01	3.47	3.08	2.72	3.54	1.81
C18:1n-9	12.31	9.16	29.90	54.61	59.68	41.64	32.52	17.48	15.41
C18:2n-6	11.22	10.35	17.56	16.77	10.98	20.63	38.50	19.83	17.10
C20:0	0.45	0.11	0.12	0.11	0.16	0.36	0.13	0.09	0.14
C20:1n-9	0.13	0.06	0.06	0.07	0.06	0.08	0.21	0.07	0.08
C18:3n-3	5.21	1.33	1.57	1.70	1.40	8.99	1.70	37.68	45.99
C20:2n-6	2.11	0.61	0.42	0.57	0.29	0.43	0.54	0.40	0.54
C22:1n-9	0.00	0.00	0.00	0.00	0.00	5.21	0.00	0.00	0.00
C20:4n-6	1.48	0.26	0.43	0.24	0.22	0.16	0.12	0.26	0.19
C20:4n-3	0.42	0.11	0.07	0.09	0.03	0.07	0.14	0.09	0.07
C20:5n-3	8.83	2.96	3.53	3.68	2.61	2.73	2.30	2.86	2.14
C22:5n-3	0.67	0.18	0.27	0.19	0.15	0.15	0.12	0.18	0.22
C22:6n-3	10.34	2.82	2.27	2.26	2.17	2.51	2.38	2.83	1.94
ΣSFA[2]	29.85	69.46	39.56	16.97	19.59	15.05	17.46	15.30	12.86
ΣMUFA[3]	18.87	10.96	31.94	56.68	61.37	48.50	34.49	19.09	17.12
ΣPUFA[4]	42.58	18.84	26.43	25.77	17.95	35.81	46.00	64.34	68.45
Σn-6 PUFA[5]	15.42	11.45	18.71	17.85	11.59	21.36	39.36	20.69	18.09
Σn-3 PUFA[6]	27.15	7.40	7.72	7.92	6.36	14.45	6.63	43.65	50.36
ΣLC-PUFA[7]	25.68	6.95	6.99	7.03	5.51	6.05	5.59	6.63	5.10

n-3 / n-6 PUFA	1.76	0.65	0.41	0.44	0.55	0.68	0.17	2.11	2.78

[1] Others: included 25 % fishmeal (72.7 % crude protein, 8.9 % total lipid, 1.5 % 20:4n-6, 14.9 % 20:5n-3, 15.8 % 22:6n-3), 12 % fermented soybean meal (54.8 % crude protein, 2.0 % total lipid), 28 % soya concentrate (70.9 % crude protein), 2 % vitamin and 2 %mineral premixes (obtained from Yuequn Ocean Biological Research Development Co. Ltd., Jieyang, Guangdong, China), 5 % α-Starch, 12 % Cassava starch, 2 % Soybean lecithin, 0.8 % $Ca(H_2PO_4)$, 0.2 % Lutein, 0.5 % Choline chloride, 0.5 % Betaine and 3 % Microcrystalline cellulose; [2] ΣSFA is the sum of saturated fatty acids; [3] ΣMUFA is the sum of monounsaturated fatty acids; [4] ΣPUFA is the sum of polyunsaturated fatty acids (PUFA); [5] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [6] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [7] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Table 2. Growth performance, feed efficiency, and biometrical parameters of juvenile pompano *T. ovatus* fed the experimental diets for 8 weeks.

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
Initial weight (g)	10.69 ± 0.15	10.60 ± 0.13	10.56 ± 0.13	10.61 ± 0.11	10.59 ± 0.09	10.59 ± 0.08	10.64 ± 0.13	10.55 ± 0.09	10.49 ± 0.08
Final weight (g)	45.51 ± 1.11^{ab}	49.65 ± 3.01^{b}	39.42 ± 1.88^{a}	45.00 ± 2.72^{ab}	41.58 ± 1.08^{ab}	42.44 ± 1.17^{ab}	42.37 ± 0.67^{ab}	40.78 ± 2.17^{ab}	49.68 ± 1.60^{b}
SR (%)[1]	86.67 ± 3.85	84.44 ± 1.11	83.33 ± 3.33	87.78 ± 1.11	81.11 ± 9.87	91.11 ± 2.93	88.89 ± 1.11	94.44 ± 2.93	93.33 ± 5.09
WG (%)[2]	325.72 ± 6.61^{ab}	368.49 ± 29.31^{b}	272.97 ± 14.31^{a}	323.90 ± 23.28^{ab}	292.83 ± 13.03^{ab}	300.47 ± 8.48^{ab}	298.29 ± 11.16^{ab}	286.98 ± 23.50^{ab}	373.78 ± 15.01^{b}
SGR (% / day)[3]	2.59 ± 0.03^{ab}	2.75 ± 0.11^{b}	2.35 ± 0.07^{a}	2.57 ± 0.10^{ab}	2.44 ± 0.06^{ab}	2.48 ± 0.04^{ab}	2.47 ± 0.05^{ab}	2.41 ± 0.11^{ab}	2.78 ± 0.06^{b}
FCR[4]	1.74 ± 0.05	1.54 ± 0.12	2.05 ± 0.12	1.77 ± 0.15	1.89 ± 0.07	1.81 ± 0.06	1.84 ± 0.05	2.03 ± 0.16	1.58 ± 0.06
VSI (%)[5]	6.84 ± 0.36^{a}	9.16 ± 0.43^{b}	8.84 ± 0.62^{ab}	8.90 ± 0.51^{ab}	8.58 ± 0.47^{ab}	7.48 ± 0.49^{ab}	7.72 ± 0.38^{ab}	7.51 ± 0.57^{ab}	7.59 ± 0.02^{ab}
HSI (%)[6]	2.01 ± 0.11^{a}	3.02 ± 0.01^{b}	3.01 ± 0.29^{b}	2.91 ± 0.22^{ab}	2.82 ± 0.09^{ab}	2.49 ± 0.26^{ab}	2.42 ± 0.14^{ab}	2.63 ± 0.17^{ab}	2.19 ± 0.14^{ab}
CF (%)[7]	3.44 ± 0.08^{a}	3.66 ± 0.08^{ab}	3.49 ± 0.03^{ab}	3.79 ± 0.07^{b}	3.53 ± 0.04^{ab}	3.64 ± 0.01^{ab}	3.58 ± 0.09^{ab}	3.63 ± 0.02^{ab}	3.63 ± 0.06^{ab}

Values are means ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$).

[1] Survival rate (SR, %) = 100 × (final fish number / initial fish number); [2] Weight gain (WG, %) = 100 × ((Final body weight − Initial body weight) / Initial body weight); [3] Specific growth rate (SGR, % day^{-1}) = 100 × ((Ln (final body weight) − Ln (initial body weight)) / days); [4] Feed conversion rate (FCR) = (total dry weight of feed fed) / (final weight − initial weight); [5] Viscerosomatic index (VSI %) = 100 × (viscera weight (g) / whole body weight); [6] Hepatosomatic index (HSI %) = 100 × (liver weight (g) / whole body weight); [7] Condition factor (CF, %) =100 × (fish weight (g) / fish length (cm)^3).

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Table 3. Whole body composition （% wet matter basis）of juvenile pompano *T. ovatus* fed the experimental diets for 8 weeks.

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
Moisture	65.77 ± 0.50	66.95 ± 0.79	66.53 ± 1.73	63.39 ± 0.92	65.04 ± 0.76	65.77 ± 1.01	64.35 ± 0.23	66.18 ± 0.28	65.09 ± 1.38
Crude protein	17.12 ± 0.40^{b}	16.51 ± 0.22^{ab}	15.64 ± 0.10^{a}	16.90 ± 0.07^{b}	16.76 ± 0.12^{b}	16.98 ± 0.12^{b}	17.16 ± 0.32^{b}	17.26 ± 0.04^{b}	17.14 ± 0.04^{b}
Total lipid	15.87 ± 0.71^{a}	18.19 ± 0.33^{bc}	17.13 ± 0.50^{abc}	18.61 ± 0.24^{c}	17.59 ± 0.18^{abc}	17.44 ± 0.37^{abc}	18.62 ± 0.68^{c}	16.28 ± 0.41^{ab}	15.48 ± 0.63^{a}
Ash	3.61 ± 0.10^{bc}	3.13 ± 0.16^{ab}	3.64 ± 0.04^{bc}	3.19 ± 0.09^{ab}	3.56 ± 0.05^{bc}	3.92 ± 0.07^{c}	3.50 ± 0.23^{abc}	2.99 ± 0.10^{a}	3.36 ± 0.05^{abc}

Values are mean ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$).

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Table 4. The serum biochemistry indices of juvenile pompano *T. ovatus* fed the experimental diets for 8 weeks.

arameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
DL （mmol / L） [1]	2.41 ± 0.04	2.19 ± 0.15	2.11 ± 0.23	2.13 ± 0.09	2.13 ± 0.01	2.03 ± 0.07	2.25 ± 0.05	2.04 ± 0.12	1.91 ± 0.17
DL （mmol / L） [2]	0.21 ± 0.01^{a}	0.30 ± 0.01^{a}	0.29 ± 0.02^{a}	0.55 ± 0.03^{b}	0.56 ± 0.05^{b}	0.30 ± 0.03^{a}	0.22 ± 0.02^{a}	0.30 ± 0.03^{a}	0.32 ± 0.02^{a}
G （mmol / L） [3]	2.00 ± 0.19	2.04 ± 0.15	2.12 ± 0.22	2.82 ± 0.41	2.63 ± 0.28	2.77 ± 0.41	2.08 ± 0.24	1.85 ± 0.17	2.30 ± 0.22
-CHO （mmol / L） [4]	10.47 ± 0.25	7.66 ± 0.15	8.85 ± 0.07	10.49 ± 0.81	10.58 ± 1.45	10.72 ± 0.56	9.88 ± 1.01	9.74 ± 0.07	9.46 ± 0.13
EFA （μmol / L） [5]	170.45 ± 22.73^{b}	56.82 ± 6.56^{a}	79.55 ± 6.56^{a}	196.97 ± 23.04^{b}	242.42 ± 26.52^{b}	223.48 ± 15.15^{b}	178.03 ± 26.52^{b}	193.18 ± 13.12^{b}	193.18 ± 6.56^{b}
LT （U / L） [6]	1.96 ± 0.23^{a}	2.75 ± 0.16^{a}	3.05 ± 0.16^{a}	3.37 ± 0.32^{a}	2.31 ± 0.15^{a}	3.04 ± 0.45^{a}	1.77 ± 0.28^{a}	5.94 ± 0.69^{b}	2.99 ± 0.19^{a}
ST （U / L） [7]	1.64 ± 0.09^{abc}	1.84 ± 0.20^{abc}	2.20 ± 0.34^{bc}	2.05 ± 0.22^{abc}	2.46 ± 0.14^{c}	1.69 ± 0.20^{abc}	1.44 ± 0.13^{ab}	1.19 ± 0.01^{a}	1.64 ± 0.09^{abc}

Values are mean ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$). ND, not detected.

[1] HDL: high-density lipoprotein; [2] LDL: low-density lipoprotein; [3] TG: triglyceride; [4] T-CHO: total-cholesterol; [5] NEFA: non-esterified fatty acid; [6] ALT: alanine aminotransferase; [7] AST: aspartate aminotransferase.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Table 5. Antioxidation parameters in serum and liver of juvenile pompano *T. ovatus* fed the experimental diets for 8 weeks.

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
Serum									
MDA (nmol / mL)[1]	8.85 ± 0.24^{bc}	7.62 ± 0.15^{ab}	9.41 ± 0.3^{c}	8.51 ± 0.20^{abc}	8.35 ± 0.24^{abc}	8.40 ± 0.35^{abc}	7.34 ± 0.06^{a}	8.51 ± 0.34^{abc}	7.73 ± 0.39^{ab}
GSH-PX (μmol / L)[2]	244.91 ± 8.73^{c}	245.59 ± 4.79^{c}	168.29 ± 3.13^{a}	207.29 ± 8.54^{b}	210.71 ± 4.93^{bc}	206.60 ± 5.85^{b}	203.87 ± 9.87^{ab}	207.29 ± 4.10^{b}	234.65 ± 11.87^{bc}
CAT (U / mL)[3]	26.30 ± 0.55^{b}	25.97 ± 1.33^{b}	18.64 ± 1.42^{a}	25.58 ± 0.24^{b}	23.59 ± 1.01^{b}	24.25 ± 1.31^{b}	24.84 ± 0.54^{b}	26.48 ± 0.24^{b}	27.81 ± 0.60^{b}
SOD (U / mL)[4]	13.29 ± 0.35^{bcd}	15.53 ± 0.43^{d}	11.10 ± 0.20^{ab}	14.16 ± 0.60^{cd}	14.04 ± 0.86^{cd}	13.09 ± 0.20^{abcd}	10.36 ± 0.88^{a}	12.08 ± 0.80^{abc}	13.25 ± 0.22^{bcd}
T-AOC (mM)[5]	0.52 ± 0.05^{c}	0.53 ± 0.01^{c}	0.28 ± 0.02^{ab}	0.38 ± 0.04^{abc}	0.43 ± 0.03^{bc}	0.43 ± 0.0.3^{bc}	0.22 ± 0.02^{a}	0.31 ± 0.05^{ab}	0.54 ± 0.05^{c}
Liver									
MDA (nmol / mgprot)[1]	1.97 ± 0.45^{ab}	0.94 ± 0.04^{a}	2.88 ± 0.04^{b}	1.43 ± 0.24^{a}	1.02 ± 0.03^{a}	1.08 ± 0.09^{a}	1.79 ± 0.02^{ab}	2.61 ± 0.25^{b}	1.87 ± 0.25^{ab}
GSH-PX (U / mgprot)[2]	499.77 ± 9.62^{c}	453.09 ± 27.70^{c}	285.45 ± 25.38^{a}	310.84 ± 12.66^{ab}	337.28 ± 27.43^{ab}	395.86 ± 2.58^{bc}	344.77 ± 12.46^{ab}	267.82 ± 22.38^{a}	338.84 ± 29.73^{ab}
CAT (U / mgprot)[3]	19.72 ± 0.86^{c}	16.88 ± 0.69^{bc}	11.64 ± 0.60^{a}	14.97 ± 0.61^{ab}	14.26 ± 0.98^{ab}	14.78 ± 0.94^{ab}	19.26 ± 0.28^{c}	13.78 ± 0.75^{ab}	17.33 ± 0.84^{bc}
SOD (U / mgprot)[4]	12.17 ± 0.61^{bcd}	15.71 ± 0.10^{e}	11.58 ± 1.01^{bc}	14.56 ± 0.24^{de}	8.98 ± 0.47^{a}	11.54 ± 0.31^{bc}	12.69 ± 0.28^{bcd}	10.31 ± 0.55^{ab}	12.81 ± 0.16^{cd}
T-AOC (mM / mgprot)[5]	0.69 ± 0.02^{cd}	0.72 ± 0.02^{cd}	0.68 ± 0.01^{cd}	0.71 ± 0.01^{cd}	0.50 ± 0.01^{a}	0.62 ± 0.05^{bc}	0.78 ± 0.01^{d}	0.57 ± 0.01^{ab}	0.69 ± 0.03^{cd}

Values are mean ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$).

[1] MDA: malondialdehyde; [2] GSH-PX: glutathione peroxidase activity; [3] CAT: catalase activity; [4] SOD: superoxide dismutase activity; [5] T-AOC: total antioxidant capacity activity.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Table 6. Tissue lipid deposition of total lipid (mg / g), neutral lipid (mg / g) and polar lipid (mg / g) of juvenile *Trachinotus ovatus* fed with experimental diets for 8 weeks.

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
Liver									
Total lipid	215.21 ± 10.88^{ab}	252.11 ± 17.63^{bc}	285.06 ± 2.67^{c}	375.33 ± 2.18^{d}	360.72 ± 4.91^{d}	275.78 ± 6.34^{c}	187.48 ± 4.41^{a}	246.28 ± 12.51^{bc}	335.19 ± 12.37^{d}
NL[1]	166.53 ± 3.22^{ab}	202.72 ± 10.73^{bc}	212.29 ± 3.73^{c}	291.32 ± 2.43^{e}	296.08 ± 15.69^{e}	232.41 ± 8.42^{cd}	162.06 ± 3.32^{a}	221.62 ± 8.87^{c}	263.48 ± 6.33^{de}
PL[2]	48.67 ± 8.36^{abc}	49.39 ± 7.12^{abc}	72.77 ± 1.2^{bc}	83.98 ± 1.02^{c}	64.64 ± 11.07^{bc}	43.37 ± 4.21^{ab}	25.42 ± 3.64^{a}	24.66 ± 5.01^{a}	71.71 ± 13.09^{bc}
NL / PL[3]	3.64 ± 0.65^{a}	4.21 ± 0.38^{a}	2.92 ± 0.99^{a}	3.47 ± 0.06^{a}	4.89 ± 0.93^{a}	5.49 ± 0.70^{a}	6.64 ± 0.92^{ab}	9.66 ± 1.65^{b}	3.96 ± 0.65^{a}
Dorsal muscle									
Total lipid	58.92 ± 1.90^{bc}	66.45 ± 1.78^{c}	70.11 ± 0.47^{cde}	83.58 ± 3.56^{e}	81.91 ± 6.85^{de}	61.13 ± 1.73^{bc}	68.05 ± 1.63^{cd}	37.76 ± 2.26^{a}	50.44 ± 2.62^{ab}
NL[1]	49.36 ± 1.11^{bc}	61.24 ± 1.61^{cd}	64.16 ± 0.32^{cd}	76.64 ± 4.13^{d}	75.01 ± 7.35^{d}	55.68 ± 1.61^{bc}	63.28 ± 1.99^{cd}	30.06 ± 1.89^{a}	41.09 ± 1.70^{ab}
PL[2]	9.56 ± 0.79^{c}	5.21 ± 0.29^{ab}	5.96 ± 0.18^{ab}	6.94 ± 0.75^{abc}	6.90 ± 0.51^{abc}	5.45 ± 0.20^{ab}	4.77 ± 3.17^{a}	7.69 ± 0.48^{bc}	9.35 ± 1.05^{c}
NL / PL[3]	5.21 ± 0.29^{ab}	11.80 ± 0.54^{b}	10.79 ± 0.28^{b}	11.40 ± 1.68^{b}	11.16 ± 1.96^{b}	10.23 ± 0.32^{b}	13.50 ± 1.37^{b}	3.91 ± 0.18^{a}	4.48 ± 0.39^{a}
Ventral muscle									
Total lipid	186.99 ± 1.93^{c}	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NL[1]	172.35 ± 2.52^{b}	83.37 ± 3.82^{a}	90.43 ± 3.47^{a}	146.52 ± 11.76^{bc}	134.90 ± 4.69^{b}	78.98 ± 7.63^{a}	170.99 ± 9.93^{b}	137.02 ± 3.61^{b}	133.13 ± 6.04^{b}
PL[2]	14.64 ± 1.30^{a}	15.77 ± 0.90^{ab}	19.51 ± 1.01^{ab}	19.57 ± 1.11^{ab}	18.62 ± 3.10^{ab}	18.48 ± 0.52^{ab}	22.45 ± 1.24^{b}	16.94 ± 0.62^{ab}	14.05 ± 0.83^{a}
NL / PL[3]	11.99 ± 1.26^{c}	5.33 ± 0.43^{ab}	4.67 ± 0.34^{a}	7.59 ± 0.99^{abc}	7.79 ± 1.68^{abc}	4.26 ± 0.31^{a}	7.70 ± 0.82^{abc}	8.11 ± 0.41^{abc}	9.59 ± 0.95^{bc}

Values are mean ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$).

[1] NL: neutral lipids; [2] PL: polar lipids; [3] NL / PL: the ratio of neutral lipids to polar lipids.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

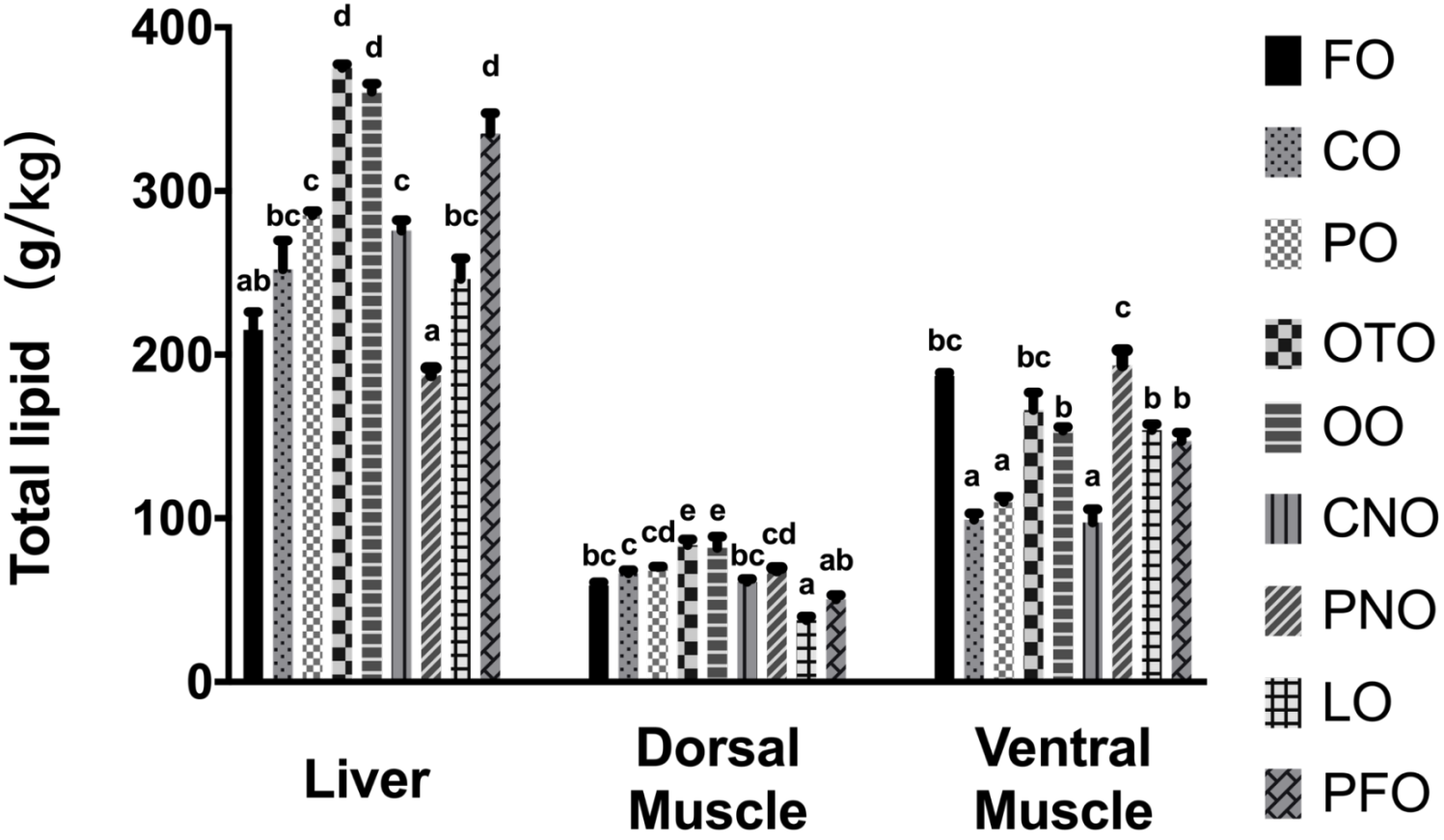

Fig. 1. Tissue total lipid (g / kg, wet matter basis) in liver, dorsal muscle and ventral muscle of juvenile *Trachinotus ovatus* fed different experimental diets for 8 weeks.

Values are mean ± SE (n = 3). Means values in the same row with different superscripts are significantly different ($P < 0.05$).

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

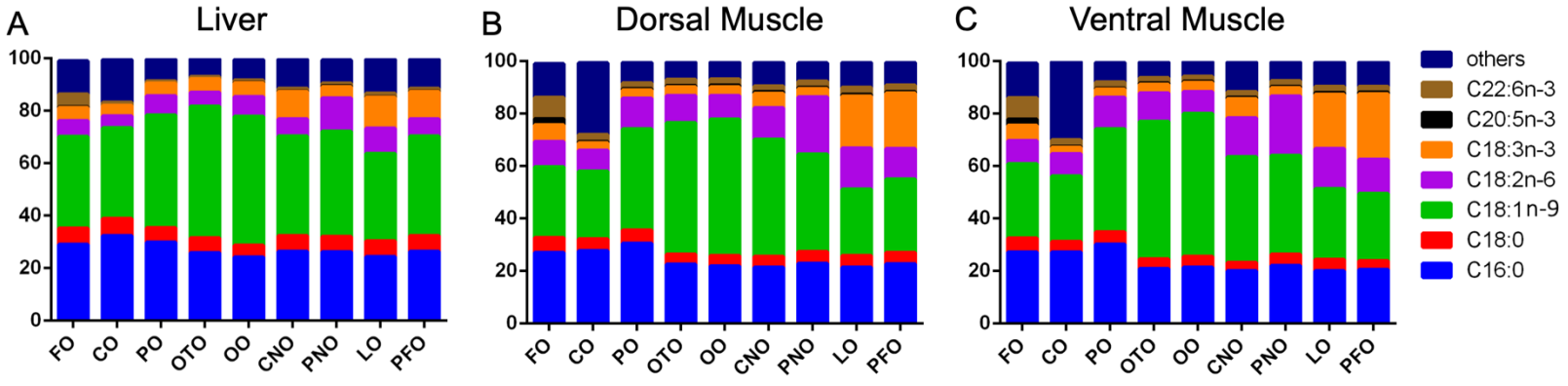

Fig. 2.

Proportions (% total fatty acids) of selected fatty acids in neutral lipid of liver (A), dorsal muscle (B) and ventral muscle (C) of pompano fed the experimental diets for 8 weeks.

Note: complete neutral lipid fatty acid composition is detailed in **Supplementary Table 1**.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

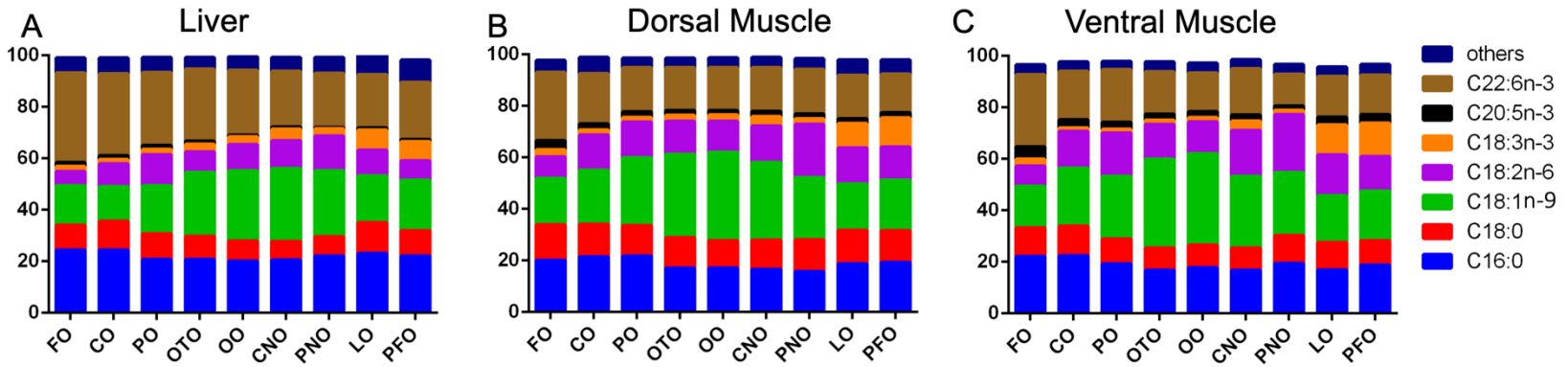

Fig. 3. Proportions (% total fatty acids) of selected fatty acids in polar lipid of liver (A), dorsal muscle (B) and ventral muscle (C) of pompano fed the experimental diets for 8 weeks.

Note: complete polar lipid fatty acid composition is detailed in **Supplementary Table 1**.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

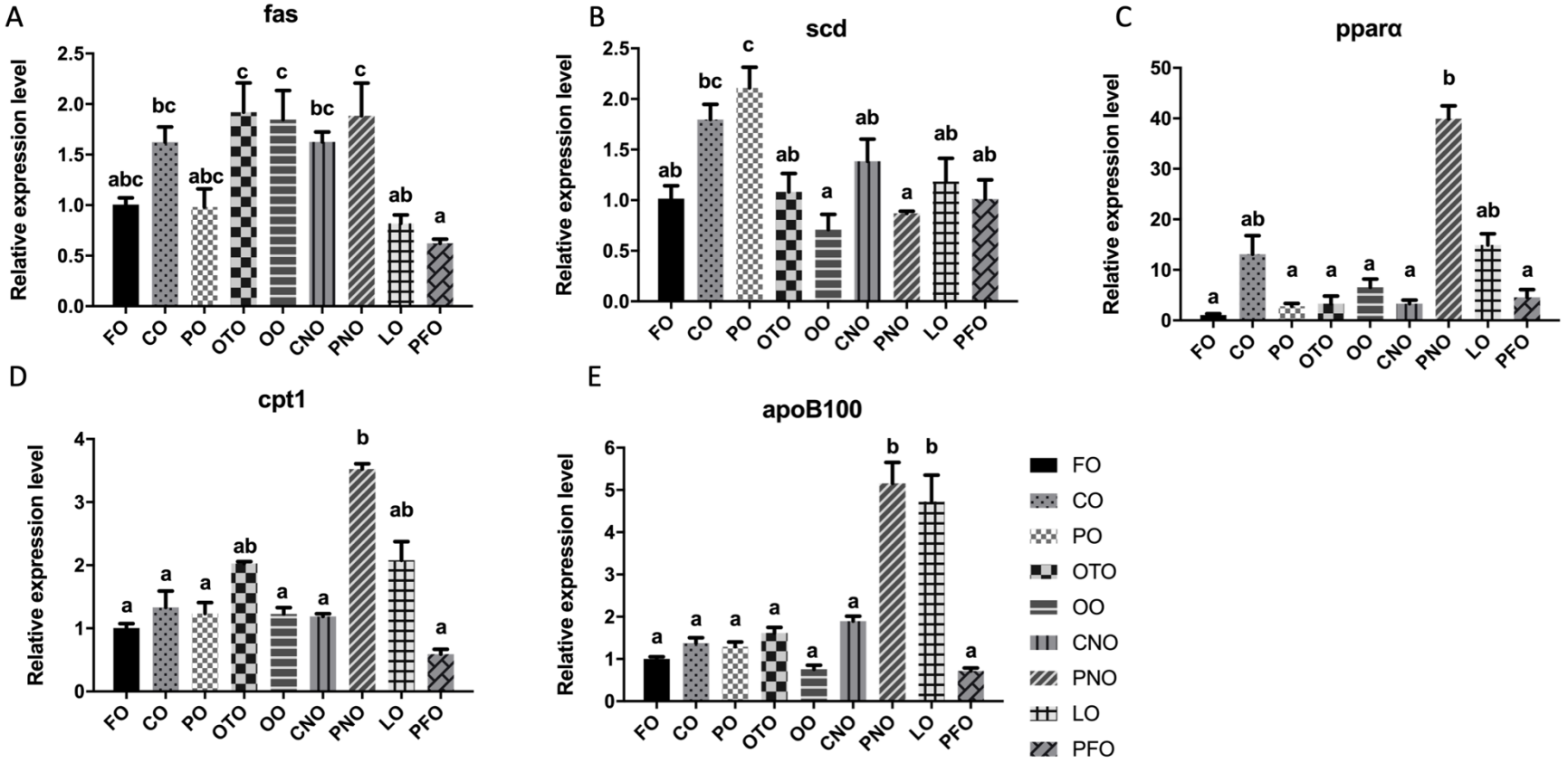

Fig. 4. Relative mRNA expression level of *fas* (A), *scd* (B), *pparα* (C), *cpt1* (D) and *apoB100* (E) in liver of pompano fed the experimental diets for 8 weeks. Values of columns for the same gene with different superscripts are significantly different ($P < 0.05$).

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 1. The fatty acid composition of neutral lipids of liver (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	ND	1.71 ± 0.21^{b}	0.05 ± 0.01^{a}	0.02 ± 0.00^{a}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}	ND	ND	ND
C14:0	1.81 ± 0.04^{a}	6.49 ± 0.95^{b}	1.36 ± 0.09^{a}	1.08 ± 0.01^{a}	1.16 ± 0.07^{a}	1.15 ± 0.04^{a}	1.00 ± 0.02^{a}	0.86 ± 0.04^{a}	0.95 ± 0.04^{a}
C16:0	26.62 ± 0.42^{ab}	30.94 ± 0.40^{c}	28.81 ± 0.68^{bc}	25.21 ± 0.11^{ab}	23.58 ± 0.43^{a}	24.01 ± 0.64^{a}	25.34 ± 1.96^{ab}	25.34 ± 0.63^{a}	25.31 ± 1.00^{ab}
C16:1n-9	3.29 ± 0.06^{b}	3.34 ± 0.27^{b}	2.21 ± 0.17^{a}	1.85 ± 0.03^{a}	2.00 ± 0.05^{a}	1.84 ± 0.08^{a}	1.83 ± 0.10^{a}	1.64 ± 0.07^{a}	1.93 ± 0.11^{a}
C18:0	5.64 ± 0.21^{ab}	6.27 ± 0.53^{b}	5.26 ± 0.35^{ab}	5.45 ± 0.05^{ab}	4.28 ± 0.27^{a}	4.64 ± 0.28^{ab}	5.67 ± 0.61^{ab}	5.60 ± 0.56^{ab}	5.74 ± 0.14^{ab}
C18:1n-9	32.44 ± 1.00^{a}	33.51 ± 1.50^{ab}	41.45 ± 0.80^{cd}	48.55 ± 0.05^{f}	47.61 ± 1.98^{ef}	42.61 ± 0.62^{de}	38.49 ± 0.55^{bcd}	31.75 ± 1.43^{a}	36.08 ± 0.50^{abc}
C18:2n-6	5.93 ± 0.19^{a}	4.51 ± 0.21^{a}	7.28 ± 0.53^{ab}	5.50 ± 0.02^{a}	7.58 ± 2.27^{ab}	8.28 ± 0.85^{ab}	12.37 ± 2.37^{b}	9.43 ± 0.63^{ab}	6.40 ± 0.34^{a}
C20:0	0.25 ± 0.01^{ab}	0.23 ± 0.01^{ab}	0.22 ± 0.01^{ab}	0.18 ± 0.00^{a}	0.15 ± 0.07^{a}	0.24 ± 0.00^{ab}	0.34 ± 0.01^{b}	0.20 ± 0.01^{a}	0.20 ± 0.00^{a}
C20:1n-9	0.03 ± 0.01	0.02 ± 0.02	0.05 ± 0.00	0.05 ± 0.00	0.02 ± 0.01	0.02 ± 0.01	0.04 ± 0.01	0.04 ± 0.01	0.03 ± 0.01
C18:3n-3	0.03 ± 0.01^{a}	2.83 ± 1.39^{ab}	3.89 ± 0.21^{ab}	4.32 ± 0.32^{abc}	4.77 ± 0.35^{bc}	5.14 ± 0.24^{bc}	5.44 ± 0.36^{bc}	4.90 ± 0.56^{bc}	8.74 ± 2.29^{c}
C20:2n-6	1.73 ± 0.05^{a}	1.57 ± 0.13^{a}	1.79 ± 0.03^{a}	1.39 ± 0.06^{a}	1.65 ± 0.25^{a}	1.95 ± 0.21^{ab}	2.90 ± 0.44^{b}	2.04 ± 0.20^{ab}	1.46 ± 0.06^{a}
C20:3n-6	0.15 ± 0.01^{b}	0.07 ± 0.01^{ab}	0.06 ± 0.00^{ab}	0.04 ± 0.01^{a}	0.07 ± 0.00^{ab}	0.07 ± 0.00^{ab}	0.11 ± 0.01^{ab}	0.09 ± 0.04^{ab}	0.10 ± 0.03^{ab}
C22:1n-9	0.82 ± 0.03^{b}	0.06 ± 0.00^{a}	0.04 ± 0.00^{a}	0.02 ± 0.01^{a}	0.04 ± 0.00^{a}	0.02 ± 0.01^{a}	0.05 ± 0.00^{a}	0.04 ± 0.02^{a}	0.08 ± 0.00^{a}
C20:3n-3	2.50 ± 0.02^{ab}	1.95 ± 0.08^{a}	1.93 ± 0.06^{a}	1.82 ± 0.04^{a}	2.04 ± 0.17^{a}	3.64 ± 0.20^{b}	1.79 ± 0.02^{a}	6.68 ± 0.79^{c}	5.72 ± 0.18^{c}
C20:4n-6	0.13 ± 0.02^{bc}	0.07 ± 0.01^{abc}	0.05 ± 0.00^{a}	0.05 ± 0.00^{ab}	0.12 ± 0.01^{abc}	0.13 ± 0.01^{abc}	0.13 ± 0.03^{c}	0.09 ± 0.02^{abc}	0.06 ± 0.03^{abc}
C20:4n-3	0.55 ± 0.05^{bc}	0.41 ± 0.08^{abc}	0.36 ± 0.02^{abc}	0.22 ± 0.01^{a}	0.32 ± 0.07^{abc}	0.29 ± 0.03^{ab}	0.59 ± 0.11^{bc}	0.60 ± 0.05^{c}	0.34 ± 0.06^{abc}
C24:0	0.36 ± 0.01^{b}	0.08 ± 0.01^{a}	0.06 ± 0.00^{a}	0.06 ± 0.01^{a}	0.08 ± 0.00^{a}	0.09 ± 0.00^{a}	0.08 ± 0.01^{a}	0.10 ± 0.02^{a}	0.08 ± 0.02^{a}
C20:5n-3	1.44 ± 0.06^{d}	0.75 ± 0.04^{a}	0.82 ± 0.01^{ab}	0.72 ± 0.05^{a}	0.86 ± 0.05^{ab}	1.42 ± 0.02^{d}	0.81 ± 0.05^{ab}	1.22 ± 0.10^{cd}	1.06 ± 0.02^{bc}
C22:5n-3	1.00 ± 0.10^{b}	0.14 ± 0.02^{a}	0.16 ± 0.02^{a}	0.16 ± 0.00^{a}	0.14 ± 0.01^{a}	0.11 ± 0.01^{a}	0.14 ± 0.03^{a}	0.22 ± 0.02^{a}	0.15 ± 0.03^{a}
C22:6n-3	4.44 ± 0.19^{b}	1.04 ± 0.05^{a}	0.77 ± 0.05^{a}	0.77 ± 0.01^{a}	0.84 ± 0.01^{a}	0.87 ± 0.10^{a}	0.99 ± 0.07^{a}	1.28 ± 0.18^{a}	1.10 ± 0.10^{a}
ΣSFA[1]	34.68 ± 0.66^{ab}	45.71 ± 0.86^{c}	35.76 ± 0.61^{b}	32.00 ± 0.15^{ab}	29.25 ± 0.54^{a}	30.13 ± 0.89^{ab}	32.42 ± 2.59^{ab}	30.10 ± 1.20^{a}	32.28 ± 0.94^{ab}
ΣMUFA[2]	36.58 ± 0.91^{ab}	36.93 ± 1.32^{ab}	43.75 ± 0.73^{c}	50.47 ± 0.07^{e}	49.66 ± 1.96^{de}	44.50 ± 0.71^{cd}	40.41 ± 0.66^{bc}	33.47 ± 1.50^{a}	38.09 ± 0.60^{ab}
ΣPUFA[3]	22.06 ± 0.46^{abcd}	14.29 ± 0.52^{a}	17.62 ± 0.20^{abc}	15.81 ± 0.17^{ab}	18.63 ± 2.32^{abcd}	22.58 ± 1.33^{bcd}	24.12 ± 3.02^{cd}	33.28 ± 2.39^{e}	26.77 ± 1.36^{de}
Σn-6 PUFA[4]	7.94 ± 0.24^{a}	6.22 ± 0.33^{a}	9.18 ± 0.54^{ab}	6.98 ± 0.05^{a}	9.42 ± 2.52^{ab}	10.42 ± 1.04^{ab}	15.50 ± 2.81^{b}	11.65 ± 0.81^{ab}	8.02 ± 0.41^{a}
Σn-3 PUFA[5]	14.12 ± 0.23^{c}	8.07 ± 0.27^{a}	8.44 ± 0.38^{a}	8.83 ± 0.12^{ab}	9.21 ± 0.43^{ab}	12.16 ± 0.30^{bc}	8.61 ± 0.27^{a}	21.63 ± 1.67^{d}	18.75 ± 0.95^{d}
ΣLC-PUFA[6]	11.93 ± 0.32^{d}	6.00 ± 0.36^{ab}	5.93 ± 0.13^{ab}	5.16 ± 0.15^{a}	6.04 ± 0.25^{ab}	8.47 ± 0.34^{bc}	7.45 ± 0.70^{abc}	12.21 ± 1.19^{d}	9.99 ± 0.42^{cd}
n-3/n-6 PUFA	1.78 ± 0.03^{cd}	1.30 ± 0.06^{bc}	0.93 ± 0.10^{ab}	1.26 ± 0.01^{bc}	1.12 ± 0.27^{ab}	1.19 ± 0.09^{b}	0.59 ± 0.08^{a}	1.86 ± 0.08^{de}	2.34 ± 0.01^{e}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different ($P<0.05$). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 2. The fatty acid composition of neutral lipids of dorsal muscle (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	ND	9.65 ± 0.63^{b}	0.46 ± 0.07^{a}	0.06 ± 0.01^{a}	0.02 ± 0.00^{a}	ND	ND	ND	ND
C14:0	3.00 ± 0.07^{c}	9.94 ± 0.15^{d}	2.05 ± 0.07^{b}	1.42 ± 0.07^{a}	1.32 ± 0.02^{a}	1.49 ± 0.04^{a}	1.33 ± 0.01^{a}	1.37 ± 0.08^{a}	1.27 ± 0.01^{a}
C16:0	23.88 ± 0.59^{bc}	26.17 ± 0.38^{c}	29.19 ± 0.19^{d}	21.47 ± 0.86^{a}	20.61 ± 0.27^{a}	20.05 ± 0.60^{a}	21.62 ± 0.03^{ab}	20.17 ± 0.41^{a}	21.66 ± 0.41^{ab}
C16:1n-9	4.11 ± 0.09^{d}	3.31 ± 0.07^{c}	2.62 ± 0.11^{b}	2.31 ± 0.16^{ab}	2.38 ± 0.02^{ab}	2.13 ± 0.04^{a}	2.18 ± 0.02^{ab}	2.03 ± 0.16^{a}	2.39 ± 0.05^{ab}
C18:0	4.93 ± 0.07^{b}	4.24 ± 0.05^{ab}	4.72 ± 0.30^{b}	3.64 ± 0.08^{a}	3.82 ± 0.11^{a}	3.76 ± 0.15^{a}	4.29 ± 0.06^{ab}	4.26 ± 0.22^{ab}	4.22 ± 0.19^{ab}
C18:1n-9	24.30 ± 1.52^{a}	24.34 ± 0.33^{a}	36.92 ± 0.40^{bc}	47.75 ± 1.25^{d}	49.15 ± 0.55^{d}	41.50 ± 2.01^{c}	35.02 ± 0.20^{b}	23.98 ± 0.13^{a}	26.73 ± 0.10^{a}
C18:2n-6	9.20 ± 0.83^{ab}	7.80 ± 0.03^{a}	11.26 ± 0.13^{b}	10.35 ± 0.28^{ab}	9.01 ± 0.32^{ab}	11.76 ± 1.73^{bc}	20.62 ± 0.22^{d}	14.89 ± 0.25^{c}	11.32 ± 0.07^{b}
C20:0	0.38 ± 0.01^{d}	0.21 ± 0.01^{ab}	0.25 ± 0.00^{b}	0.17 ± 0.01^{a}	0.25 ± 0.01^{bc}	0.30 ± 0.02^{c}	0.55 ± 0.01^{e}	0.22 ± 0.01^{ab}	0.20 ± 0.00^{a}
C20:1n-9	0.01 ± 0.00^{a}	0.03 ± 0.02^{ab}	0.01 ± 0.00^{a}	0.05 ± 0.00^{ab}	0.03 ± 0.01^{ab}	0.03 ± 0.01^{ab}	0.03 ± 0.01^{ab}	0.07 ± 0.00^{b}	0.05 ± 0.01^{ab}
C18:3n-3	6.25 ± 0.27^{c}	2.80 ± 0.07^{a}	3.25 ± 0.04^{a}	3.46 ± 0.13^{a}	3.65 ± 0.05^{ab}	5.51 ± 1.00^{bc}	3.22 ± 0.09^{a}	19.55 ± 0.34^{d}	20.59 ± 0.49^{d}
C20:2n-6	0.83 ± 0.10^{ab}	1.07 ± 0.05^{bc}	1.14 ± 0.04^{c}	1.00 ± 0.03^{abc}	0.93 ± 0.04^{abc}	1.15 ± 0.09^{c}	1.80 ± 0.02^{d}	1.08 ± 0.05^{bc}	0.76 ± 0.01^{a}
C20:3n-6	0.18 ± 0.02^{a}	0.10 ± 0.01^{a}	0.10 ± 0.01^{a}	0.10 ± 0.01^{a}	0.11 ± 0.01^{a}	0.08 ± 0.00^{a}	1.03 ± 0.06^{b}	0.11 ± 0.01^{a}	0.08 ± 0.01^{a}
C22:1n-9	1.13 ± 0.04^{b}	0.11 ± 0.02^{a}	0.06 ± 0.01^{a}	0.06 ± 0.02^{a}	0.09 ± 0.01^{a}	2.98 ± 0.07^{b}	0.06 ± 0.01^{a}	0.07 ± 0.00^{a}	0.03 ± 0.01^{a}
C20:3n-3	1.47 ± 0.07^{b}	0.96 ± 0.05^{a}	0.88 ± 0.02^{a}	0.90 ± 0.04^{a}	0.97 ± 0.02^{a}	0.99 ± 0.02^{a}	0.88 ± 0.04^{a}	4.21 ± 0.11^{d}	3.79 ± 0.14^{c}
C20:4n-6	0.17 ± 0.03^{b}	0.10 ± 0.01^{ab}	0.06 ± 0.02^{a}	0.08 ± 0.02^{a}	0.12 ± 0.01^{ab}	0.06 ± 0.01^{a}	0.10 ± 0.01^{ab}	0.07 ± 0.00^{a}	0.05 ± 0.01^{a}
C20:4n-3	0.26 ± 0.04^{bcd}	0.30 ± 0.01^{cd}	0.24 ± 0.02^{abc}	0.21 ± 0.02^{ab}	0.22 ± 0.02^{abc}	0.22 ± 0.00^{abc}	0.35 ± 0.00^{d}	0.28 ± 0.02^{bcd}	0.16 ± 0.01^{a}
C24:0	2.05 ± 0.08^{b}	0.45 ± 0.01^{a}	0.50 ± 0.03^{a}	0.51 ± 0.02^{a}	0.51 ± 0.01^{a}	0.53 ± 0.02^{a}	0.49 ± 0.01^{a}	0.60 ± 0.01^{a}	0.55 ± 0.02^{a}
C20:5n-3	0.79 ± 0.09^{c}	0.56 ± 0.02^{abc}	0.38 ± 0.02^{a}	0.45 ± 0.05^{ab}	0.53 ± 0.06^{abc}	0.74 ± 0.11^{c}	0.44 ± 0.03^{ab}	0.69 ± 0.03^{bc}	0.57 ± 0.04^{abc}
C22:5n-3	2.38 ± 0.12^{c}	0.87 ± 0.01^{b}	0.72 ± 0.02^{ab}	0.69 ± 0.02^{ab}	0.70 ± 0.04^{ab}	0.60 ± 0.04^{a}	0.77 ± 0.01^{ab}	0.73 ± 0.02^{ab}	0.69 ± 0.03^{ab}
C22:6n-3	7.22 ± 0.13^{b}	2.60 ± 0.19^{a}	2.04 ± 0.01^{a}	2.22 ± 0.06^{a}	2.28 ± 0.21^{a}	2.10 ± 0.06^{a}	2.22 ± 0.08^{a}	2.58 ± 0.16^{a}	2.24 ± 0.09^{a}
ΣSFA[1]	34.24 ± 0.60^{b}	50.67 ± 0.55^{d}	37.16 ± 0.34^{c}	27.27 ± 0.88^{a}	26.54 ± 0.32^{a}	26.13 ± 0.71^{a}	28.28 ± 0.06^{a}	26.63 ± 0.40^{a}	27.89 ± 0.59^{a}
ΣMUFA[2]	29.55 ± 1.52^{a}	27.80 ± 0.29^{a}	39.61 ± 0.41^{b}	50.17 ± 1.08^{cd}	51.65 ± 0.56^{d}	46.64 ± 1.97^{c}	37.29 ± 0.17^{b}	26.15 ± 0.18^{a}	29.20 ± 0.13^{a}
ΣPUFA[3]	28.74 ± 1.63^{cd}	17.17 ± 0.23^{a}	20.08 ± 0.27^{ab}	19.46 ± 0.24^{ab}	18.52 ± 0.66^{ab}	23.21 ± 3.00^{bc}	31.42 ± 0.06^{d}	44.19 ± 0.43^{e}	40.27 ± 0.59^{e}
Σn-6 PUFA[4]	10.37 ± 0.97^{ab}	9.07 ± 0.08^{a}	12.56 ± 0.19^{ab}	11.53 ± 0.28^{ab}	10.18 ± 0.37^{ab}	13.05 ± 1.80^{bc}	23.55 ± 0.19^{d}	16.15 ± 0.30^{c}	12.22 ± 0.06^{ab}
Σn-3 PUFA[5]	18.37 ± 0.66^{c}	8.09 ± 0.18^{ab}	7.51 ± 0.08^{a}	7.93 ± 0.22^{ab}	8.34 ± 0.31^{ab}	10.17 ± 1.20^{b}	7.87 ± 0.20^{ab}	28.03 ± 0.20^{d}	28.05 ± 0.55^{d}
ΣLC-PUFA[6]	13.29 ± 0.56^{e}	6.56 ± 0.25^{ab}	5.57 ± 0.10^{a}	5.65 ± 0.14^{a}	5.86 ± 0.40^{a}	5.94 ± 0.27^{a}	7.58 ± 0.14^{bc}	9.74 ± 0.22^{d}	8.36 ± 0.24^{cd}
n-3/n-6 PUFA	1.79 ± 0.10^{d}	0.89 ± 0.02^{c}	0.60 ± 0.00^{b}	0.69 ± 0.03^{bc}	0.82 ± 0.02^{c}	0.78 ± 0.02^{bc}	0.33 ± 0.01^{a}	1.74 ± 0.03^{d}	2.30 ± 0.04^{e}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different ($P<0.05$). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 3. The fatty acid composition of neutral lipids of ventral muscle (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	0.03 ± 0.00^{a}	12.19 ± 1.59^{b}	0.03 ± 0.01^{a}	0.04 ± 0.01^{a}	ND	ND	ND	ND	ND
C14:0	3.03 ± 0.15^{b}	11.30 ± 0.60^{c}	1.88 ± 0.12^{a}	1.29 ± 0.10^{a}	1.18 ± 0.02^{a}	1.52 ± 0.07^{a}	1.25 ± 0.07^{a}	1.24 ± 0.06^{a}	1.43 ± 0.03^{a}
C16:0	24.76 ± 0.39^{b}	26.48 ± 0.26^{b}	29.27 ± 0.20^{c}	20.24 ± 0.46^{a}	20.77 ± 0.07^{a}	19.32 ± 0.51^{a}	20.84 ± 0.72^{a}	19.22 ± 0.63^{a}	20.03 ± 0.63^{a}
C16:1n-9	4.46 ± 0.22^{c}	3.57 ± 0.03^{b}	2.45 ± 0.11^{a}	2.02 ± 0.14^{a}	2.17 ± 0.04^{a}	2.22 ± 0.06^{a}	2.08 ± 0.14^{a}	1.94 ± 0.07^{a}	2.36 ± 0.05^{a}
C18:0	4.68 ± 0.45^{c}	3.85 ± 0.07^{abc}	4.41 ± 0.24^{bc}	3.46 ± 0.24^{abc}	4.11 ± 0.05^{abc}	3.08 ± 0.15^{a}	4.10 ± 0.21^{abc}	3.99 ± 0.18^{abc}	3.21 ± 0.39^{ab}
C18:1n-9	25.86 ± 0.72^{a}	24.23 ± 0.48^{a}	38.10 ± 0.59^{b}	50.26 ± 0.78^{c}	52.82 ± 0.34^{c}	38.79 ± 0.33^{b}	35.60 ± 1.21^{b}	25.70 ± 1.14^{a}	24.94 ± 1.09^{a}
C18:2n-6	8.43 ± 0.26^{a}	8.23 ± 0.17^{a}	11.81 ± 0.26^{b}	10.62 ± 0.24^{ab}	8.27 ± 0.29^{a}	14.40 ± 0.65^{c}	21.53 ± 0.81^{d}	14.87 ± 0.73^{c}	12.78 ± 0.68^{bc}
C20:0	0.40 ± 0.02^{c}	0.22 ± 0.02^{ab}	0.27 ± 0.01^{b}	0.18 ± 0.01^{ab}	0.25 ± 0.01^{ab}	0.38 ± 0.01^{c}	0.59 ± 0.04^{d}	0.22 ± 0.01^{ab}	0.16 ± 0.02^{a}
C20:1n-9	0.05 ± 0.00^{ab}	0.08 ± 0.01^{b}	0.08 ± 0.00^{b}	0.06 ± 0.02^{ab}	0.06 ± 0.01^{ab}	0.06 ± 0.02^{ab}	0.03 ± 0.01^{a}	0.06 ± 0.00^{ab}	0.08 ± 0.01^{ab}
C18:3n-3	5.28 ± 0.04^{ab}	2.45 ± 0.19^{a}	3.09 ± 0.08^{a}	3.41 ± 0.14^{a}	3.45 ± 0.03^{a}	7.17 ± 0.16^{b}	3.19 ± 0.06^{a}	20.25 ± 0.97^{c}	24.39 ± 1.49^{d}
C20:2n-6	0.70 ± 0.03^{a}	1.01 ± 0.11^{abc}	1.26 ± 0.06^{bc}	1.05 ± 0.02^{abc}	0.81 ± 0.04^{a}	1.42 ± 0.12^{c}	1.95 ± 0.18^{d}	1.10 ± 0.04^{abc}	0.83 ± 0.03^{ab}
C20:3n-6	0.12 ± 0.00^{a}	0.13 ± 0.01^{a}	0.13 ± 0.00^{a}	0.12 ± 0.00^{a}	0.10 ± 0.01^{a}	0.14 ± 0.02^{a}	1.03 ± 0.12^{b}	0.15 ± 0.01^{a}	0.19 ± 0.05^{a}
C22:1n-9	1.18 ± 0.06^{a}	ND	ND	ND	ND	ND	3.74 ± 0.09^{b}	ND	ND
C20:3n-3	1.41 ± 0.05^{b}	0.76 ± 0.14^{a}	0.91 ± 0.10^{ab}	0.89 ± 0.06^{ab}	1.01 ± 0.09^{ab}	1.25 ± 0.03^{ab}	0.86 ± 0.03^{ab}	4.17 ± 0.24^{c}	4.03 ± 0.20^{c}
C20:4n-6	0.10 ± 0.01	0.05 ± 0.02	0.06 ± 0.00	0.04 ± 0.01	0.06 ± 0.01	0.06 ± 0.01	0.08 ± 0.02	0.07 ± 0.00	0.08 ± 0.02
C20:4n-3	0.18 ± 0.03^{ab}	0.22 ± 0.05^{ab}	0.18 ± 0.02^{ab}	0.17 ± 0.02^{ab}	0.10 ± 0.02^{a}	0.23 ± 0.02^{ab}	0.41 ± 0.05^{c}	0.26 ± 0.00^{b}	0.13 ± 0.02^{ab}
C24:0	2.25 ± 0.07^{b}	0.43 ± 0.00^{a}	0.45 ± 0.01^{a}	0.46 ± 0.01^{a}	0.44 ± 0.02^{a}	0.51 ± 0.01^{a}	0.49 ± 0.04^{a}	0.56 ± 0.04^{a}	0.58 ± 0.01^{a}
C20:5n-3	0.71 ± 0.04^{b}	0.40 ± 0.11^{a}	0.42 ± 0.02^{a}	0.44 ± 0.05^{ab}	0.36 ± 0.03^{a}	1.07 ± 0.05^{c}	0.37 ± 0.06^{a}	0.49 ± 0.02^{ab}	0.31 ± 0.08^{a}
C22:5n-3	2.36 ± 0.06^{b}	0.61 ± 0.22^{a}	0.78 ± 0.01^{a}	0.70 ± 0.03^{a}	0.65 ± 0.02^{a}	0.64 ± 0.06^{a}	0.77 ± 0.06^{a}	0.77 ± 0.01^{a}	0.68 ± 0.00^{a}

C22:6n-3	7.30 ± 0.14^{c}	2.38 ± 0.09^{b}	2.14 ± 0.08^{ab}	2.01 ± 0.02^{ab}	1.84 ± 0.05^{a}	2.09 ± 0.13^{ab}	2.10 ± 0.13^{ab}	2.22 ± 0.11^{ab}	2.12 ± 0.09^{ab}
ΣSFA[1]	35.14 ± 0.35^{b}	54.45 ± 1.90^{a}	36.59 ± 0.13^{b}	25.66 ± 0.34^{a}	26.75 ± 0.06^{a}	24.80 ± 0.64^{a}	27.26 ± 0.68^{a}	25.24 ± 0.74^{a}	25.40 ± 0.99^{a}
ΣMUFA[2]	31.55 ± 0.52^{b}	27.88 ± 0.50^{ab}	40.63 ± 0.50^{c}	52.33 ± 0.63^{e}	55.06 ± 0.34^{e}	44.80 ± 0.32^{d}	37.71 ± 1.24^{c}	27.69 ± 1.16^{a}	27.39 ± 1.03^{a}
ΣPUFA[3]	26.60 ± 0.57^{bc}	16.25 ± 0.87^{a}	20.77 ± 0.41^{ab}	19.44 ± 0.22^{a}	16.64 ± 0.37^{a}	28.47 ± 1.03^{c}	32.29 ± 1.50^{c}	44.36 ± 1.82^{d}	45.55 ± 2.45^{d}
Σn-6 PUFA[4]	9.35 ± 0.30^{a}	9.42 ± 0.24^{a}	13.26 ± 0.32^{bc}	11.82 ± 0.25^{ab}	9.23 ± 0.32^{a}	16.03 ± 0.79^{c}	24.59 ± 1.12^{d}	16.19 ± 0.76^{c}	13.88 ± 0.77^{bc}
Σn-3 PUFA[5]	17.24 ± 0.30^{c}	6.83 ± 0.67^{a}	7.52 ± 0.16^{a}	7.62 ± 0.19^{a}	7.41 ± 0.08^{a}	12.44 ± 0.32^{b}	7.70 ± 0.38^{a}	28.17 ± 1.29^{d}	31.66 ± 1.68^{d}
ΣLC-PUFA[6]	12.89 ± 0.30^{f}	5.56 ± 0.58^{ab}	5.87 ± 0.18^{abc}	5.41 ± 0.07^{ab}	4.92 ± 0.09^{a}	6.90 ± 0.35^{bcd}	7.57 ± 0.63^{cde}	9.24 ± 0.39^{e}	8.38 ± 0.31^{de}
n-3/n-6 PUFA	1.85 ± 0.03^{d}	0.72 ± 0.06^{bc}	0.57 ± 0.01^{b}	0.65 ± 0.02^{bc}	0.80 ± 0.03^{c}	0.78 ± 0.03^{c}	0.31 ± 0.00^{a}	1.74 ± 0.07^{d}	2.28 ± 0.01^{e}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different (P<0.05). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids.

FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 4. The fatty acid composition of polar lipids of liver (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0	0.58 ± 0.03^{b}	1.07 ± 0.06^{c}	0.32 ± 0.10^{ab}	0.26 ± 0.02^{a}	0.40 ± 0.09^{ab}	0.55 ± 0.05^{ab}	0.50 ± 0.03^{ab}	0.25 ± 0.08^{a}	0.28 ± 0.06^{ab}
C16:0	23.59 ± 0.33^{b}	22.89 ± 0.59^{ab}	19.74 ± 1.25^{a}	20.07 ± 0.30^{ab}	19.36 ± 0.53^{a}	19.57 ± 0.10^{a}	21.10 ± 0.91^{ab}	22.89 ± 1.20^{ab}	21.65 ± 0.57^{ab}
C16:1[1]	1.08 ± 0.04	0.88 ± 0.09	0.89 ± 0.18	0.61 ± 0.02	0.85 ± 0.15	0.98 ± 0.04	1.07 ± 0.08	0.59 ± 0.12	0.75 ± 0.06
C18:0	9.08 ± 0.26^{cd}	10.84 ± 0.17^{ef}	9.55 ± 0.73^{de}	8.70 ± 0.28^{bcd}	7.47 ± 0.15^{abc}	6.79 ± 0.17^{a}	7.35 ± 0.22^{ab}	11.85 ± 0.44^{f}	9.74 ± 0.15^{de}
C18:1[2]	14.73 ± 0.21^{a}	12.13 ± 0.72^{a}	17.69 ± 2.02^{ab}	23.78 ± 0.32^{bc}	26.15 ± 3.75^{bc}	26.84 ± 0.47^{c}	24.75 ± 0.80^{bc}	17.93 ± 2.42^{ab}	19.23 ± 1.03^{abc}
C18:2n-6	5.19 ± 0.25^{a}	8.64 ± 0.21^{ab}	11.52 ± 1.72^{ab}	7.81 ± 0.10^{ab}	9.76 ± 2.54^{ab}	10.21 ± 1.17^{ab}	13.02 ± 1.91^{b}	9.93 ± 0.54^{ab}	7.38 ± 0.20^{ab}
C20:0	0.19 ± 0.02^{bcd}	0.13 ± 0.01^{ab}	0.16 ± 0.01^{abc}	0.12 ± 0.01^{a}	0.19 ± 0.02^{bcd}	0.20 ± 0.01^{cd}	0.24 ± 0.02^{d}	0.21 ± 0.01^{cd}	0.20 ± 0.01^{bcd}
C20:1n-9	0.20 ± 0.00	0.10 ± 0.01	0.13 ± 0.01	0.10 ± 0.02	0.08 ± 0.01	0.08 ± 0.01	0.37 ± 0.27	0.08 ± 0.01	0.09 ± 0.00
C18:3n-3	1.97 ± 0.03^{ab}	1.63 ± 0.02^{a}	2.13 ± 0.25^{ab}	2.90 ± 0.05^{b}	2.90 ± 0.41^{b}	4.16 ± 0.06^{c}	2.68 ± 0.19^{ab}	7.80 ± 0.15^{d}	7.39 ± 0.36^{d}
C20:2n-6	1.43 ± 0.03^{a}	2.26 ± 0.13^{abc}	2.65 ± 0.06^{bc}	2.18 ± 0.03^{abc}	2.52 ± 0.31^{bc}	2.86 ± 0.23^{c}	3.75 ± 0.26^{d}	1.95 ± 0.18^{ab}	1.76 ± 0.15^{ab}
C20:3n-6	0.35 ± 0.25	0.21 ± 0.01	0.27 ± 0.03	0.17 ± 0.01	0.21 ± 0.04	0.15 ± 0.02	0.19 ± 0.01	0.07 ± 0.00	0.05 ± 0.01
C22:1n-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n-3	0.85 ± 0.03^{a}	0.48 ± 0.03^{a}	0.48 ± 0.06^{a}	0.46 ± 0.01^{a}	0.56 ± 0.07^{a}	1.60 ± 0.10^{b}	0.61 ± 0.01^{a}	4.29 ± 0.27^{c}	4.41 ± 0.04^{c}
C20:4n-6	2.83 ± 0.08^{cd}	2.38 ± 0.16^{d}	1.89 ± 0.11^{bc}	1.38 ± 0.05^{ab}	1.40 ± 0.16^{ab}	1.24 ± 0.01^{ab}	0.96 ± 0.09^{a}	1.62 ± 0.28^{ab}	1.40 ± 0.08^{ab}
C20:4n-3	0.37 ± 0.01^{c}	0.26 ± 0.01^{bc}	0.18 ± 0.04^{ab}	0.11 ± 0.01^{a}	0.12 ± 0.02^{ab}	0.11 ± 0.01^{a}	0.22 ± 0.03^{ab}	0.13 ± 0.06^{ab}	0.21 ± 0.01^{ab}
C24:0	1.38 ± 0.03^{bc}	1.41 ± 0.04^{c}	1.39 ± 0.32^{c}	0.99 ± 0.04^{abc}	0.72 ± 0.07^{a}	0.77 ± 0.05^{a}	0.45 ± 0.03^{a}	0.77 ± 0.13^{ab}	0.83 ± 0.09^{abc}
C20:5n-3	0.56 ± 0.04^{e}	0.48 ± 0.00^{de}	0.48 ± 0.04^{de}	0.39 ± 0.02^{bcd}	0.43 ± 0.04^{de}	0.33 ± 0.03^{abc}	0.33 ± 0.01^{abc}	0.22 ± 0.02^{a}	0.29 ± 0.02^{ab}

C22:5n-3	1.68 ± 0.01^{f}	1.64 ± 0.08^{ef}	1.35 ± 0.18^{def}	1.20 ± 0.01^{cde}	0.91 ± 0.07^{bcd}	0.80 ± 0.05^{bc}	0.66 ± 0.00^{ab}	0.33 ± 0.19^{a}	0.57 ± 0.05^{ab}
C22:6n-3	33.14 ± 0.58^{c}	31.26 ± 0.66^{c}	26.96 ± 2.44^{bc}	27.00 ± 0.52^{bc}	23.84 ± 2.09^{ab}	20.56 ± 1.57^{ab}	20.17 ± 0.43^{ab}	18.67 ± 1.64^{a}	22.98 ± 1.70^{ab}
ΣSFA[3]	34.83 ± 0.34^{d}	36.35 ± 0.40^{cd}	31.17 ± 1.58^{abc}	30.14 ± 0.36^{ab}	28.14 ± 0.72^{a}	27.89 ± 0.05^{a}	29.65 ± 0.68^{ab}	35.97 ± 1.00^{d}	32.70 ± 0.67^{bcd}
ΣMUFA[4]	16.01 ± 0.24^{ab}	13.12 ± 0.63^{a}	18.71 ± 2.20^{abc}	24.49 ± 0.34^{bcd}	27.08 ± 3.90^{cd}	27.90 ± 0.47^{d}	26.19 ± 0.61^{cd}	18.59 ± 2.54^{abc}	20.07 ± 1.09^{abcd}
ΣPUFA[5]	48.37 ± 0.97	49.24 ± 1.09	47.90 ± 1.80	43.60 ± 0.62	42.65 ± 4.26	42.02 ± 0.60	42.58 ± 1.66	45.01 ± 3.18	46.44 ± 1.81
Σn-6 PUFA[6]	9.79 ± 0.50^{a}	13.49 ± 0.48^{ab}	16.33 ± 1.69^{ab}	11.54 ± 0.18^{ab}	13.90 ± 2.96^{ab}	14.46 ± 1.38^{ab}	17.92 ± 2.26^{b}	13.58 ± 0.92^{ab}	10.60 ± 0.42^{ab}
Σn-3 PUFA[7]	38.58 ± 0.54^{c}	35.75 ± 0.61^{bc}	31.57 ± 2.66^{abc}	32.05 ± 0.50^{abc}	28.75 ± 2.04^{ab}	27.56 ± 1.48^{a}	24.66 ± 0.61^{a}	31.43 ± 2.27^{abc}	35.84 ± 1.41^{bc}
ΣHUFA[8]	41.21 ± 0.72^{c}	38.96 ± 0.91^{bc}	34.25 ± 2.62^{abc}	32.90 ± 0.59^{abc}	29.99 ± 2.60^{a}	27.65 ± 1.41^{a}	26.89 ± 0.09^{a}	27.28 ± 2.57^{a}	31.67 ± 1.98^{ab}
n-3/n-6	3.96 ± 0.17^{d}	2.65 ± 0.05^{bc}	2.00 ± 0.35^{ab}	2.78 ± 0.04^{bc}	2.21 ± 0.36^{ab}	1.96 ± 0.27^{ab}	1.43 ± 0.19^{a}	2.31 ± 0.03^{ab}	3.38 ± 0.05^{cd}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different (P<0.05). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids. FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 5. The fatty acid composition of polar lipids of dorsal muscle (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0	0.55 ± 0.15^{a}	1.60 ± 0.23^{b}	ND	ND	ND	ND	ND	ND	ND
C16:0	19.09 ± 0.40^{ab}	20.65 ± 1.83^{ab}	21.22 ± 0.88^{b}	16.62 ± 1.07^{ab}	16.55 ± 0.59^{ab}	16.39 ± 0.36^{ab}	15.29 ± 1.43^{a}	18.33 ± 0.87^{ab}	18.87 ± 1.65^{ab}
C16:1[1]	1.11 ± 0.12^{ab}	1.73 ± 0.27^{b}	1.15 ± 0.33^{ab}	0.49 ± 0.06^{a}	0.81 ± 0.11^{a}	0.48 ± 0.03^{a}	0.74 ± 0.10^{a}	0.58 ± 0.05^{a}	0.68 ± 0.07^{a}
C18:0	13.13 ± 0.90	12.30 ± 0.50	11.55 ± 0.66	11.60 ± 0.59	10.50 ± 0.48	10.98 ± 0.20	11.96 ± 0.47	12.67 ± 0.36	12.15 ± 1.37
C18:1[2]	17.01 ± 1.05^{a}	20.44 ± 0.08^{ab}	25.85 ± 1.01^{cd}	31.41 ± 0.40^{e}	33.55 ± 0.94^{e}	30.04 ± 1.59^{de}	23.50 ± 0.24^{bc}	17.71 ± 0.76^{a}	19.31 ± 1.04^{ab}
C18:2n-6	7.97 ± 0.31^{a}	13.35 ± 0.66^{b}	13.63 ± 0.32^{b}	12.31 ± 0.61^{b}	11.66 ± 0.39^{b}	14.13 ± 0.62^{b}	20.07 ± 0.24^{c}	13.79 ± 0.47^{b}	12.67 ± 0.90^{b}
C20:0	0.30 ± 0.02^{ab}	0.28 ± 0.03^{ab}	0.24 ± 0.02^{a}	0.23 ± 0.02^{a}	0.27 ± 0.02^{a}	0.20 ± 0.01^{a}	0.43 ± 0.07^{b}	0.25 ± 0.00^{a}	0.23 ± 0.02^{a}
C20:1n-9	0.28 ± 0.01^{b}	0.10 ± 0.00^{a}	0.10 ± 0.02^{a}	0.16 ± 0.04^{a}	0.12 ± 0.02^{a}	0.13 ± 0.01^{a}	0.14 ± 0.03^{a}	0.14 ± 0.02^{a}	0.09 ± 0.00^{a}
C18:3n-3	2.82 ± 0.12^{a}	1.82 ± 0.07^{a}	1.85 ± 0.07^{a}	2.31 ± 0.09^{a}	2.35 ± 0.09^{a}	3.64 ± 0.54^{a}	2.05 ± 0.10^{a}	9.34 ± 0.75^{b}	11.27 ± 0.91^{b}
C20:2n-6	1.06 ± 0.14^{a}	1.74 ± 0.24^{b}	1.59 ± 0.08^{ab}	1.69 ± 0.04^{ab}	1.62 ± 0.07^{ab}	1.86 ± 0.05^{b}	2.64 ± 0.16^{c}	1.82 ± 0.14^{b}	1.22 ± 0.10^{ab}
C20:3n-6	0.04 ± 0.02^{a}	0.08 ± 0.00^{a}	0.05 ± 0.01^{a}	0.13 ± 0.05^{ab}	0.23 ± 0.02^{bc}	0.12 ± 0.01^{ab}	0.14 ± 0.00^{abc}	0.25 ± 0.03^{c}	0.14 ± 0.00^{abc}
C22:1n-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n-3	1.46 ± 0.12^{b}	0.97 ± 0.08^{a}	0.82 ± 0.07^{a}	0.97 ± 0.12^{a}	0.96 ± 0.02^{a}	1.05 ± 0.07^{a}	0.90 ± 0.04^{a}	2.27 ± 0.08^{b}	2.23 ± 0.04^{b}
C20:4n-6	0.41 ± 0.19^{ab}	0.28 ± 0.05^{ab}	0.07 ± 0.01^{a}	0.23 ± 0.09^{ab}	0.27 ± 0.03^{ab}	0.32 ± 0.05^{ab}	0.15 ± 0.06^{a}	0.79 ± 0.29^{bc}	1.13 ± 0.11^{c}
C20:4n-3	0.39 ± 0.02	0.44 ± 0.03	0.22 ± 0.11	0.30 ± 0.00	0.24 ± 0.01	0.16 ± 0.06	0.30 ± 0.12	0.21 ± 0.06	0.25 ± 0.05
C24:0	3.27 ± 0.38^{b}	2.36 ± 0.05^{a}	2.01 ± 0.04^{a}	1.86 ± 0.14^{a}	1.77 ± 0.04^{a}	2.10 ± 0.19^{a}	1.80 ± 0.04^{a}	1.75 ± 0.12^{a}	1.87 ± 0.08^{a}
C20:5n-3	0.75 ± 0.13^{ab}	0.42 ± 0.03^{a}	1.28 ± 0.38^{b}	0.45 ± 0.09^{a}	0.36 ± 0.02^{a}	0.20 ± 0.05^{a}	0.32 ± 0.06^{a}	0.37 ± 0.05^{a}	0.29 ± 0.03^{a}
C22:5n-3	2.79 ± 0.23^{c}	1.66 ± 0.05^{b}	0.96 ± 0.24^{ab}	1.35 ± 0.07^{ab}	1.42 ± 0.11^{ab}	0.53 ± 0.16^{a}	1.32 ± 0.25^{ab}	1.00 ± 0.21^{ab}	1.02 ± 0.21^{ab}

C22:6n-3	25.34 ± 1.13^{c}	18.94 ± 0.92^{b}	16.95 ± 0.52^{ab}	16.32 ± 1.33^{ab}	16.17 ± 0.19^{ab}	16.84 ± 0.42^{ab}	16.78 ± 0.86^{ab}	16.41 ± 0.20^{ab}	14.82 ± 0.94^{a}
ΣSFA[3]	36.34 ± 1.48^{ab}	37.19 ± 1.75^{b}	35.03 ± 1.27^{ab}	30.30 ± 1.33^{ab}	29.09 ± 1.10^{a}	29.67 ± 0.29^{ab}	29.48 ± 1.77^{a}	33.01 ± 1.07^{ab}	33.12 ± 2.72^{ab}
ΣMUFA[4]	18.40 ± 1.05^{a}	22.27 ± 0.29^{ab}	27.10 ± 1.33^{cd}	32.06 ± 0.37^{e}	34.47 ± 1.03^{e}	30.66 ± 1.61^{de}	24.38 ± 0.18^{bc}	18.42 ± 0.71^{a}	20.09 ± 1.02^{ab}
ΣPUFA[5]	43.03 ± 0.93^{bcd}	39.69 ± 1.88^{abcd}	37.41 ± 1.00^{abc}	36.06 ± 2.08^{ab}	35.28 ± 0.75^{a}	38.87 ± 1.11^{abcd}	44.66 ± 1.64^{cd}	46.23 ± 0.62^{d}	45.05 ± 2.65^{cd}
Σn-6 PUFA[6]	9.47 ± 0.53^{a}	15.46 ± 0.84^{b}	15.33 ± 0.28^{b}	14.36 ± 0.46^{b}	13.78 ± 0.44^{b}	16.43 ± 0.61^{b}	23.00 ± 0.38^{b}	16.64 ± 0.35^{b}	15.17 ± 0.99^{b}
Σn-3 PUFA[7]	33.56 ± 0.99^{c}	24.23 ± 1.07^{ab}	22.08 ± 1.24^{a}	21.70 ± 1.64^{a}	21.50 ± 0.32^{a}	22.44 ± 0.50^{a}	21.67 ± 1.33^{a}	29.60 ± 0.33^{bc}	29.88 ± 1.66^{c}
ΣHUFA[8]	32.24 ± 0.97^{b}	24.52 ± 1.21^{a}	21.93 ± 1.37^{a}	21.44 ± 1.40^{a}	21.27 ± 0.32^{a}	21.09 ± 0.05^{a}	22.54 ± 1.38^{a}	23.11 ± 0.66^{a}	21.11 ± 1.07^{a}
n-3/n-6	3.57 ± 0.27^{d}	1.57 ± 0.03^{bc}	1.44 ± 0.10^{ab}	1.51 ± 0.07^{bc}	1.56 ± 0.03^{bc}	1.36 ± 0.02^{ab}	0.94 ± 0.05^{a}	1.78 ± 0.03^{bc}	1.97 ± 0.02^{b}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different (P<0.05). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids. FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.

Supplementary Table 6. The fatty acid composition of neutral lipid in ventral muscle (% total fatty acids).

Parameter	Dietary treatment								
	FO	CO	PO	OTO	OO	CNO	PNO	LO	PFO
C12:0	ND	ND	ND	ND	ND	ND	ND	ND	ND
C14:0	ND	ND	ND	ND	ND	ND	ND	ND	ND
C16:0	21.98 ± 1.29^{ab}	22.34 ± 1.46^{b}	18.97 ± 0.61^{a}	17.08 ± 1.22^{a}	17.73 ± 0.74^{ab}	17.23 ± 0.82^{ab}	19.37 ± 0.74^{ab}	16.85 ± 1.06^{a}	18.72 ± 1.21^{ab}
C16:1[1]	1.73 ± 0.38^{ab}	2.33 ± 0.42^{b}	1.09 ± 0.14^{ab}	1.60 ± 0.49^{ab}	1.86 ± 0.48^{ab}	0.56 ± 0.30^{a}	0.91 ± 0.17^{ab}	0.60 ± 0.09^{a}	0.96 ± 0.25^{ab}
C18:0	11.15 ± 1.34	11.62 ± 0.60	9.64 ± 0.21	8.96 ± 0.90	8.91 ± 0.17	8.89 ± 0.67	10.80 ± 0.17	10.71 ± 0.47	9.50 ± 0.09
C18:1[2]	16.25 ± 1.68^{a}	22.43 ± 0.92^{bcd}	25.99 ± 1.75^{de}	35.45 ± 1.52^{f}	35.54 ± 0.54^{f}	28.70 ± 0.60^{e}	24.34 ± 1.23^{cde}	18.12 ± 1.40^{ab}	19.30 ± 0.23^{abc}
C18:2n-6	7.78 ± 0.42^{a}	14.44 ± 0.13^{bcd}	16.62 ± 0.40^{de}	13.90 ± 0.81^{bc}	12.32 ± 0.55^{a}	18.40 ± 0.57^{e}	22.43 ± 0.53^{f}	15.87 ± 0.58^{cde}	13.28 ± 0.44^{bc}
C20:0	0.41 ± 0.01^{b}	0.45 ± 0.06^{b}	0.24 ± 0.03^{a}	0.21 ± 0.01^{a}	0.22 ± 0.01^{a}	0.19 ± 0.02^{a}	0.22 ± 0.02^{a}	0.24 ± 0.02^{a}	0.24 ± 0.02^{a}
C20:1n-9	0.10 ± 0.01	0.11 ± 0.02	0.10 ± 0.01	0.09 ± 0.01	0.08 ± 0.00	0.06 ± 0.02	0.10 ± 0.02	0.10 ± 0.01	0.09 ± 0.01
C18:3n-3	2.63 ± 0.16^{ab}	1.26 ± 0.19^{a}	1.60 ± 0.07^{a}	1.69 ± 0.04^{a}	1.78 ± 0.03^{ab}	3.67 ± 0.41^{b}	1.73 ± 0.05^{a}	11.67 ± 0.75^{c}	12.97 ± 0.72^{c}
C20:2n-6	0.72 ± 0.11^{a}	0.72 ± 0.02^{a}	1.15 ± 0.36^{ab}	0.97 ± 0.22^{ab}	0.76 ± 0.18^{ab}	1.70 ± 0.10^{bc}	2.12 ± 0.11^{c}	0.75 ± 0.17^{a}	1.18 ± 0.25^{abc}
C20:3n-6	0.07 ± 0.01	0.08 ± 0.00	0.06 ± 0.01	0.09 ± 0.02	0.09 ± 0.02	0.08 ± 0.00	0.11 ± 0.01	0.09 ± 0.01	0.10 ± 0.01
C22:1n-9	ND	ND	ND	ND	ND	ND	ND	ND	ND
C20:3n-3	1.45 ± 0.18^{cde}	0.49 ± 0.15^{ab}	0.86 ± 0.07^{abc}	1.38 ± 0.23^{bcde}	1.20 ± 0.21^{bcd}	1.50 ± 0.27^{cde}	0.13 ± 0.01^{a}	2.24 ± 0.25^{e}	1.94 ± 0.20^{de}
C20:4n-6	0.15 ± 0.01^{a}	0.09 ± 0.01^{a}	0.08 ± 0.01^{a}	0.09 ± 0.03^{a}	0.11 ± 0.02^{a}	0.09 ± 0.01^{a}	1.44 ± 0.34^{b}	0.09 ± 0.01^{a}	0.08 ± 0.00^{a}
C20:4n-3	0.33 ± 0.02^{c}	0.14 ± 0.01^{b}	0.13 ± 0.00^{ab}	0.12 ± 0.01^{ab}	0.13 ± 0.02^{ab}	0.10 ± 0.01^{ab}	0.08 ± 0.01^{a}	0.14 ± 0.01^{ab}	0.13 ± 0.01^{ab}
C24:0	4.80 ± 0.45^{b}	2.69 ± 0.80^{ab}	2.65 ± 0.15^{ab}	2.39 ± 0.62^{a}	2.00 ± 0.44^{a}	2.47 ± 0.60^{a}	1.30 ± 0.27^{a}	2.93 ± 0.19^{ab}	3.35 ± 0.21^{ab}
C20:5n-3	0.52 ± 0.10	0.60 ± 0.07	0.55 ± 0.02	0.56 ± 0.08	0.57 ± 0.06	0.43 ± 0.06	0.53 ± 0.06	0.45 ± 0.04	0.48 ± 0.03

C22:5n-3	0.51 ± 0.03^{b}	0.53 ± 0.10^{b}	0.40 ± 0.02^{ab}	0.46 ± 0.04^{ab}	0.42 ± 0.08^{ab}	0.21 ± 0.04^{a}	0.28 ± 0.08^{ab}	0.39 ± 0.03^{ab}	0.35 ± 0.04^{ab}
C22:6n-3	28.05 ± 1.72^{c}	18.80 ± 1.25^{b}	19.14 ± 1.22^{b}	15.04 ± 0.72^{ab}	15.04 ± 0.72^{ab}	15.02 ± 1.00^{ab}	12.22 ± 0.87^{a}	15.92 ± 0.39^{ab}	15.41 ± 0.85^{ab}
ΣSFA[3]	38.34 ± 0.14^{c}	37.10 ± 1.59^{bc}	31.50 ± 0.60^{ab}	28.64 ± 1.64^{a}	28.85 ± 0.92^{a}	28.77 ± 1.22^{a}	31.70 ± 0.62^{ab}	30.72 ± 1.38^{ab}	31.81 ± 1.51^{ab}
ΣMUFA[4]	18.09 ± 1.31^{a}	24.87 ± 1.13^{bcd}	27.17 ± 1.87^{d}	37.14 ± 1.63^{e}	37.49 ± 0.49^{e}	29.32 ± 0.83^{d}	25.34 ± 1.24^{cd}	18.82 ± 1.35^{ab}	20.34 ± 0.13^{abc}
ΣPUFA[5]	42.22 ± 1.22^{bcd}	37.16 ± 1.29^{ab}	40.58 ± 1.48^{bc}	33.47 ± 0.81^{a}	32.41 ± 0.98^{a}	41.20 ± 2.04^{bc}	41.07 ± 0.75^{bc}	47.61 ± 0.27^{d}	45.92 ± 1.56^{cd}
Σn-6 PUFA[6]	8.71 ± 0.51^{a}	15.33 ± 0.15^{bc}	17.92 ± 0.74^{de}	15.04 ± 0.69^{bc}	13.28 ± 0.42^{b}	20.28 ± 0.57^{e}	26.11 ± 0.23^{b}	16.81 ± 0.72^{cd}	14.63 ± 0.65^{bc}
Σn-3 PUFA[7]	33.50 ± 1.72^{c}	21.82 ± 1.43^{b}	22.66 ± 1.13^{b}	18.42 ± 1.37^{ab}	19.14 ± 0.76^{ab}	20.92 ± 1.69^{ab}	14.97 ± 0.94^{a}	30.80 ± 0.76^{c}	31.29 ± 0.94^{c}
ΣHUFA[8]	31.80 ± 1.75^{b}	21.45 ± 1.25^{a}	22.36 ± 1.38^{a}	17.88 ± 1.59^{a}	18.31 ± 0.59^{a}	18.31 ± 0.59^{a}	16.91 ± 1.00^{a}	20.07 ± 0.47^{a}	19.67 ± 1.27^{a}
n-3/n-6	3.90 ± 0.45^{d}	1.42 ± 0.11^{abc}	1.27 ± 0.07^{ab}	1.24 ± 0.14^{ab}	1.44 ± 0.06^{bc}	1.03 ± 0.08^{ab}	0.57 ± 0.04^{a}	1.85 ± 0.12^{bc}	2.14 ± 0.04^{c}

Notes: Values are mean ± SE (n = 3). Mean values in the same row with different superscripts are significantly different (P<0.05). ND, no detected.

[1] ΣSFA is the sum of saturated fatty acids; [2] ΣMUFA is the sum of monounsaturated fatty acids; [3] ΣPUFA is the sum of polyunsaturated fatty acids; [4] Σn-6 PUFA is the sum of n-6 polyunsaturated fatty acids; [5] Σn-3 PUFA is the sum of n-3 polyunsaturated fatty acids; [6] ΣLC-PUFA is the sum of long-chain polyunsaturated fatty acids. FO, fish oil; CO, coconut oil; PO, palm oil; OTO, oil-tea camellia oil; OO, olive oil; CNO, canola oil; PNO, peanut oil; LO, linseed oil; PFO, perilla oil.