

Evaluating lipid metabolism including cholesterol, and fatty acids



University of Idaho

Aquaculture Research Institute

Jeongwhui Hong

Aquaculture Research Institute, University of Idaho, Hagerman, Idaho, USA

jhong@uidaho.edu





FISH OIL REPLACEMENT

- Aquaculture uses most of the world's fish oil
- Fish oil is a high quality source of energy and LC-PUFAs
- Price and availability are issues
- Increased demand for alternative oil sources (e.g. soybean oil, linseed oil)
- Dietary fatty acids usually reflect tissue fatty acids composition

Source :NRC (2011)

Fatty acids	Oils		
	Fish oil	Linseed oil	Soybean oil
18:2n-6 (Linoleic acid)	0.6	12.7	51.0
18:3n-3 (α Linolenic acid)	0.4	53.3	6.8
20:4n-6 (ARA)	0.4	-	-
20:5n-3 (EPA)	8.1	-	-
22:6n-3 (DHA)	4.8	-	-



ESSENTIAL FATTY ACIDS

n-6 series

DIET

18:2
 γ -linoleic acid

18:3

20:3

20:4
 γ -arachidonic acid

22:4

22:5
docosapentaenoic acid

n-3 series

DIET

18:3
 α -linolenic acid

18:4

α -20:4

20:5
eicosapentaenoic acid

22:5

22:6
docosahexaenoic acid

PUFA

HUFA

H. Shmeeda, *Am J Physiol Regulatory Integrative Comp Physiol* 283, 392 (2002)

Human

linoleic acid (LA)
 α -linolenic acid (ALA)

Freshwater Fish

linoleic acid (LA)
 α -linolenic acid (ALA)

Marine Fish

EPA, DHA

- **PUFA** : Poly unsaturated Fatty Acids C \geq 18 and double bond \geq 2
- **HUFA** : Highly unsaturated Fatty Acids C \geq 20 and double bond \geq 2



CURRENT RESEARCH PROJECTS

Study 1.

Balancing dietary lipid and cholesterol to increase fillet omega-3 deposition in rainbow trout fed a soy-based diet.

Study 2.

Evaluation of Cargill omega-3-fortified canola oil as a fish oil substitution fed to rainbow trout (*Oncorhynchus mykiss*)



CURRENT RESEARCH PROJECTS (STUDY 1)

Study 1.

Balancing dietary lipid and cholesterol to increase fillet omega-3 deposition in rainbow trout fed a soy-based diet.

Objective:

- To determine if dietary cholesterol in different ratio of soybean oil / linseed oil can manifest any effect on growth, feed utilization performance, and fatty acid metabolism in rainbow trout**



CURRENT RESEARCH PROJECTS (STUDY 1)



CHOLESTEROL

- Cholesterol is a sterol, present in cell membrane and brain
- Precursor for all steroid
- 80% of the liver cholesterol converted to bile acids
- Cholesterol comes from two sources (diet & liver)
- Requiring 18 acetyl-CoA, 18ATP, 16NADPH and 4O₂ molecules
- Regulate FA metabolism by stimulating fatty acid β -oxidation and the conversion of ALA to DHA (Norambuena et al., 2013)

PHYTOSTEROL

- “Plant sterols”
- Inhibits intestinal cholesterol absorption

Soybean oil

300mg / 100g

Linseed oil

700mg / 100g

STUDY DESIGN (STUDY 1)



DIET	Main ingredients (%)					
	Animal protein	Plant protein	Fish oil	Soy oil	Linseed oil	Cholesterol
Diet 1 (Control)	100	-	100	-	-	-
Diet 2 (FO100)	-	-	100	-	-	-
Diet 3 (SO100)	-	-	-	100	-	-
Diet 4 (SO100+CHOL)	-	-	-	100	-	0.14
Diet 5 (SO75/ LO25)	-	-	-	75	25	-
Diet 6 (SO75/ LO25+CHOL)	-	-	-	75	25	0.14
Diet 7 (SO50/ LO50)	-	100	-	50	50	-
Diet 8 (SO50/ LO50+CHOL)	-	-	-	50	50	0.14
Diet 9 (SO25/ LO75)	-	-	-	25	75	-
Diet 10 (SO25/ LO75+CHOL)	-	-	-	25	75	0.14
Diet 11 (LO100)	-	-	-	-	100	-
Diet 12 (LO100+CHOL)	-	-	-	-	100	0.14



EXPERIMENTAL CONDITION (STUDY 1)

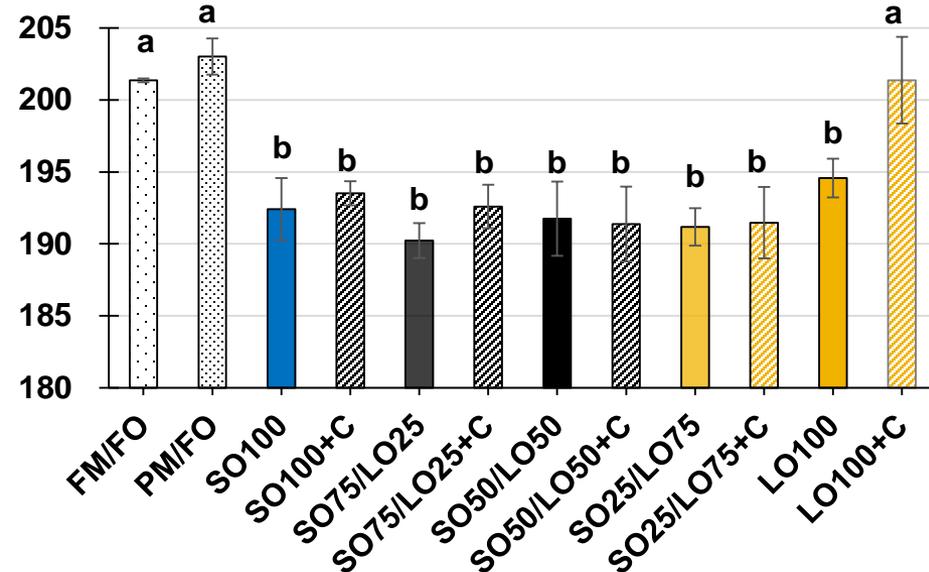
- Initial weight : $18.8 \pm 0.3\text{g}$ (mean \pm SD)
Donaldson X USDA-UI selected strain
- 25 fish / 145-L tank, triplicates
- Flow-through system, 15°C spring water
- Apparent satiation (2 times/day) for 12 weeks
- Fish were batch-weighed every three weeks



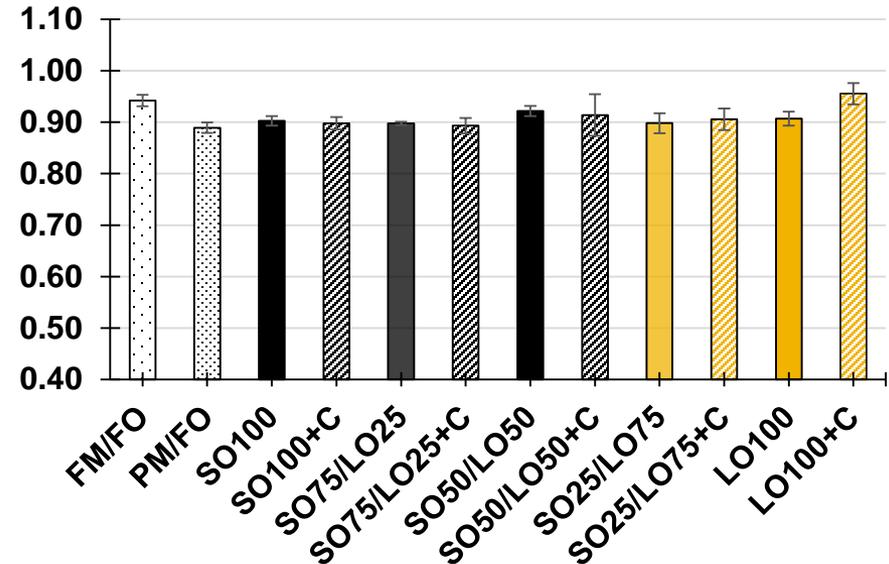


GROWTH RESULTS (STUDY 1)

Weight Gain (g / fish)



FCR



- The weight gain of fish fed diet FM/FO, PM/FO or LO100+C was greatest ($P < .05$).
- FCR was similar among dietary treatment groups ($P > .05$).



CURRENT RESEARCH PROJECTS (STUDY 2)



Study 2.

Evaluation of Cargill omega-3-fortified canola oil as a fish oil substitution fed to rainbow trout (*Oncorhynchus mykiss*)

Objective:

- To provide an evaluation of the omega-3-fortified canola oil in trout feeds and specifically the effects on trout performance, and EPA and DHA tissue composition over a complete production cycle.**



CURRENT RESEARCH PROJECTS (STUDY 2)

OMEGA-3-FORTIFIED CANOLA OIL

- Plant-based source of n-3 LC-PUFA via a genetically modified canola oil.
- EPA : DPA : DHA ratio of 9.9 : 2.4 : 1.5
- More sustainable solution to using fish oil-based aquafeed

Fatty acids	Oils	
	Fish oil	Omega-3 fortified canola oil
20:5n-3 (EPA)	16.0	9.13
22:5n-3 (DPA)	0.98	2.28
22:6n-3 (DHA)	8.99	0.91
EPA+DPA+DHA	25.9	12.3



STUDY DESIGN (STUDY 2)

Ingredient (%)	Diets		
	Diet 1 FO 6.4 / CO 0	Diet 2 FO 3.2 / CO 8	Diet 3 FO 0 / CO 16
Fishmeal sardine	20	20	20
Poultry by-product meal	12.5	12.5	12.5
Soybean meal	11.5	11.5	11.5
Soy protein concentrate	5.5	5.5	5.5
Wheat gluten meal	1.5	1.5	1.5
Corn protein conc, 75%	13.5	13.5	13.5
Wheat flour	16.2	16.2	16.2
Dicalcium phosphate	1.4	1.4	1.4
Trace mineral mix	0.1	0.1	0.1
Vitamin Premix, ARS 702	1.0	1.0	1.0
Choline chloride	0.6	0.6	0.6
Stable C (35%) vitamin	0.2	0.2	0.2
Fish oil	6.43	3.21	-
Poultry fat	9.57	4.79	-
Omega-3 canola oil	-	8.00	16.0
Nutrients (% as-fed basis)			
Protein	46.7	46.7	46.7
Fat	20.3	20.3	20.3
Gross energy (kcal/kg)	5452	5451	5450
C20:5n:3 (EPA, %)	1.25	1.47	1.69
C22:6n:3 (DHA, %)	0.81	0.59	0.38
EPA + DHA (%)	2.06	2.06	2.06



12-WEEK GROWTH RESULTS (STUDY 2)

	Diets		
	Diet 1 FO 6.4 / CO 0	Diet 2 FO 3.2 / CO 8	Diet 3 FO 0 / CO 16
Weight Gain (g / fish)	154	152	154
Feed per fish (g DM/fish)	119	119	120
Feed Conversion Ratio	0.94	0.95	0.95
Specific Growth Rate (% / d)	2.69	2.68	2.69
Survival (%)	100	97.5	100



**Thank you for
your attention!**

