INTERNATIONAL RENDERING SYMPOSIUM

The Sustainability of Circular Bioeconomies

"Rendered animal products for aquaculture: The case of fat"

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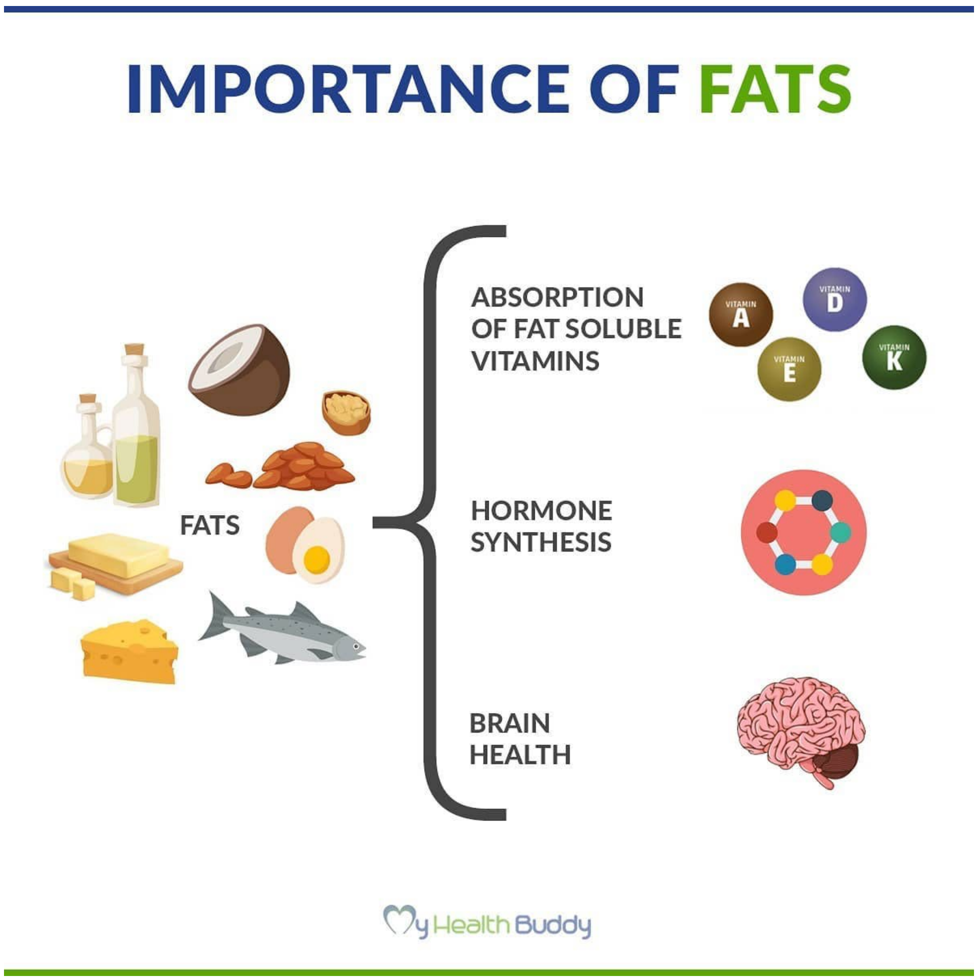
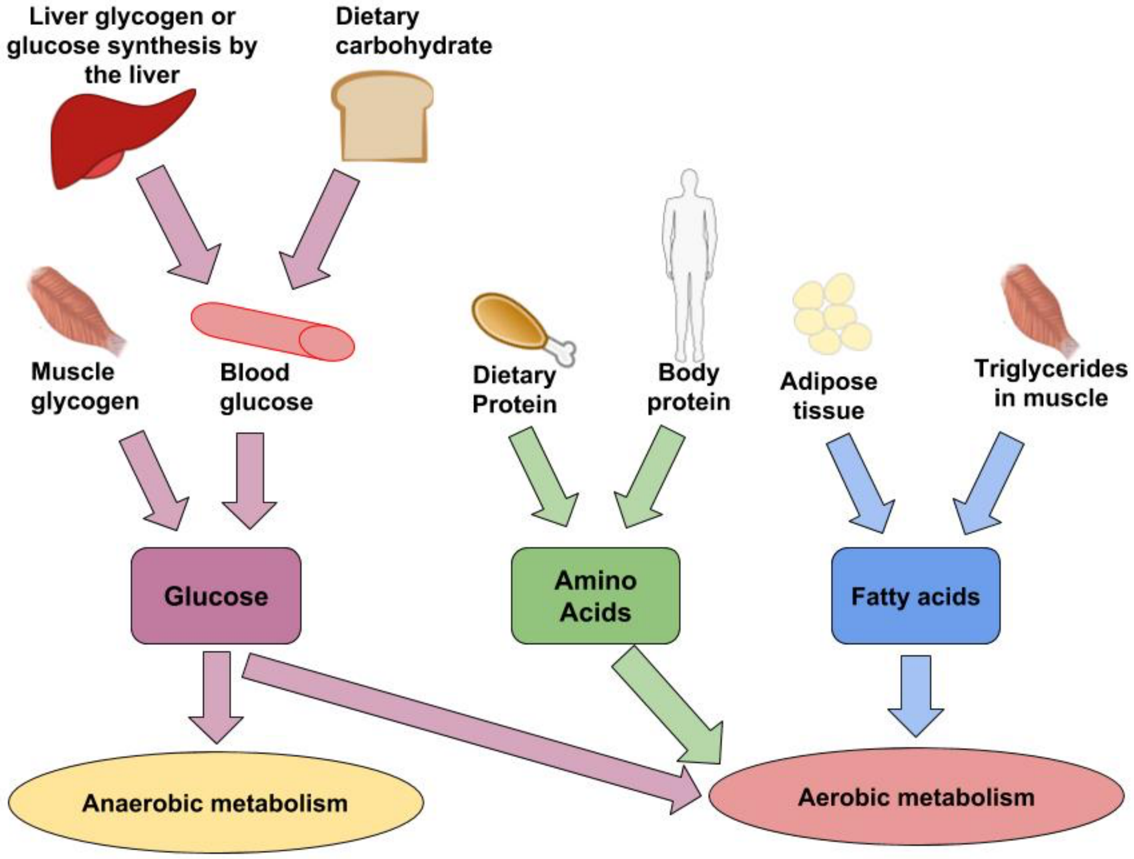
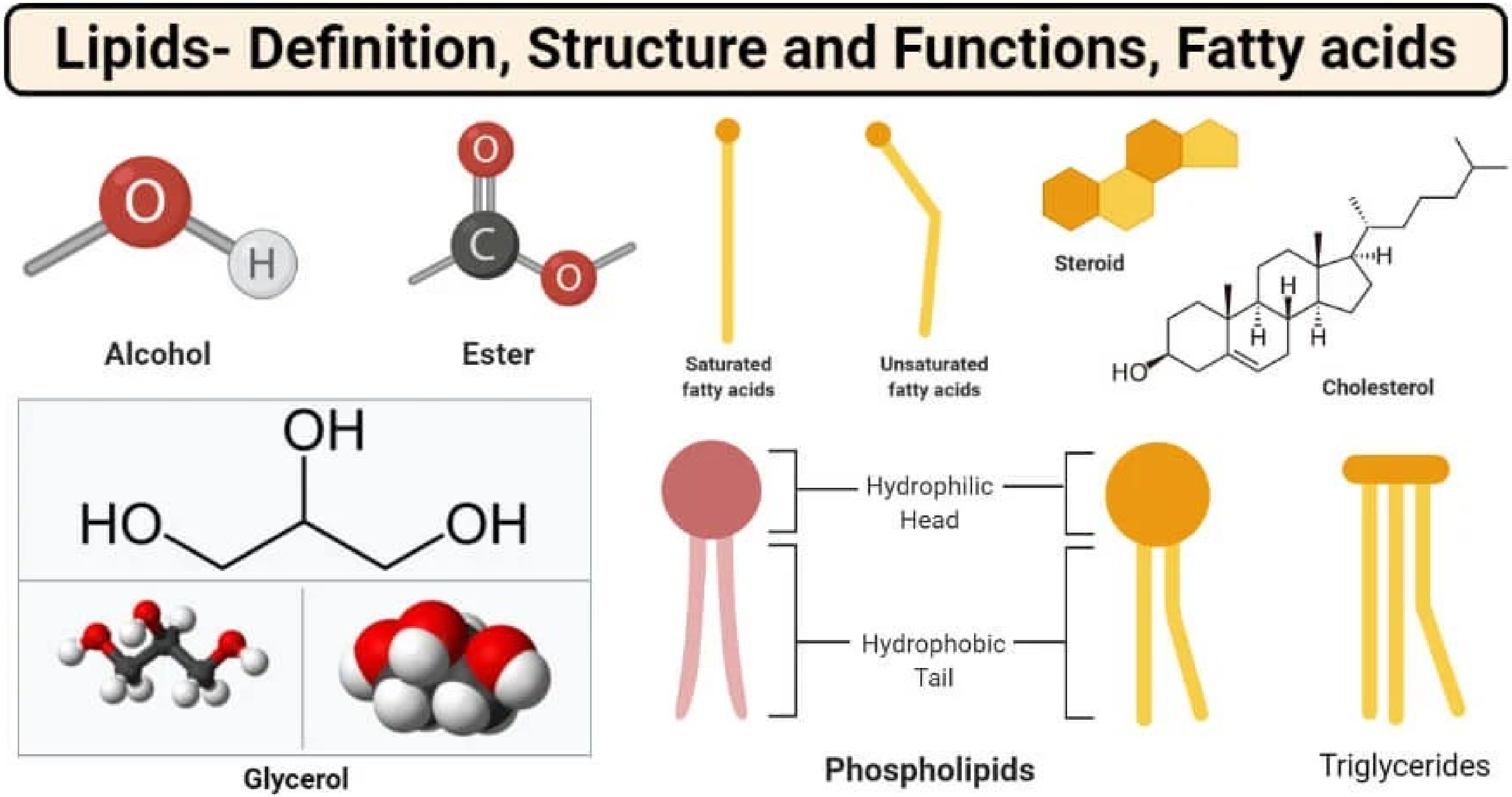
What are the fats?

- Lipids or fats are organic compounds that are easily disolved in a nonpolar solvent
- They are usually made up of glycerol with fatty acid units
- Also they can combine with or without other molecules
- They are usually hydrophobic but also they can be amphipatic

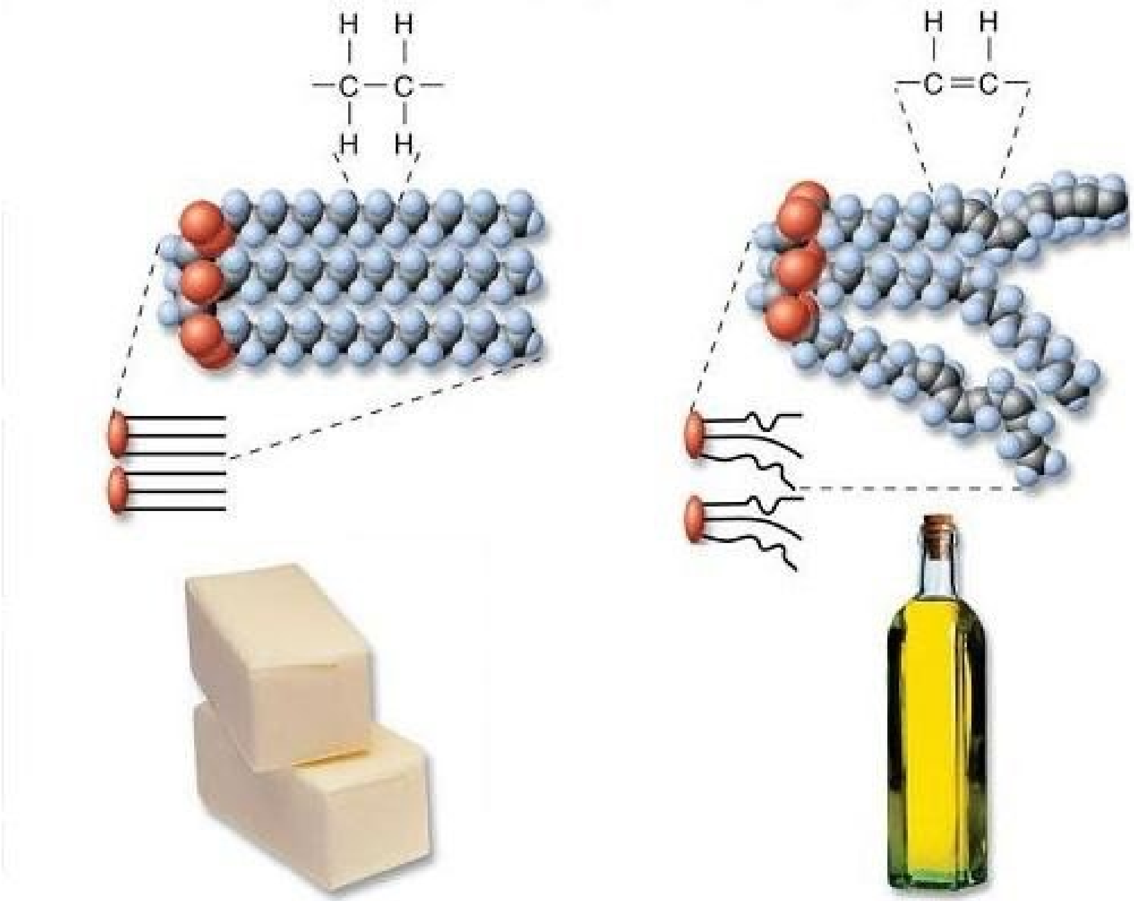


Fat is an important nutrient in metabolism and serves as an energy store in the body




Lipids- Definition, Structure and Functions, Fatty acids
O
H
Alcohol
O
C
O
Ester
Saturated
fatty acids
Unsaturated
fatty acids
Steroid
H
H
H
H
HO
Cholesterol
OH
HO
OH
Glycerol
Hydrophilic
Head
Hydrophobic
Tail
Phospholipids
Triglycerides

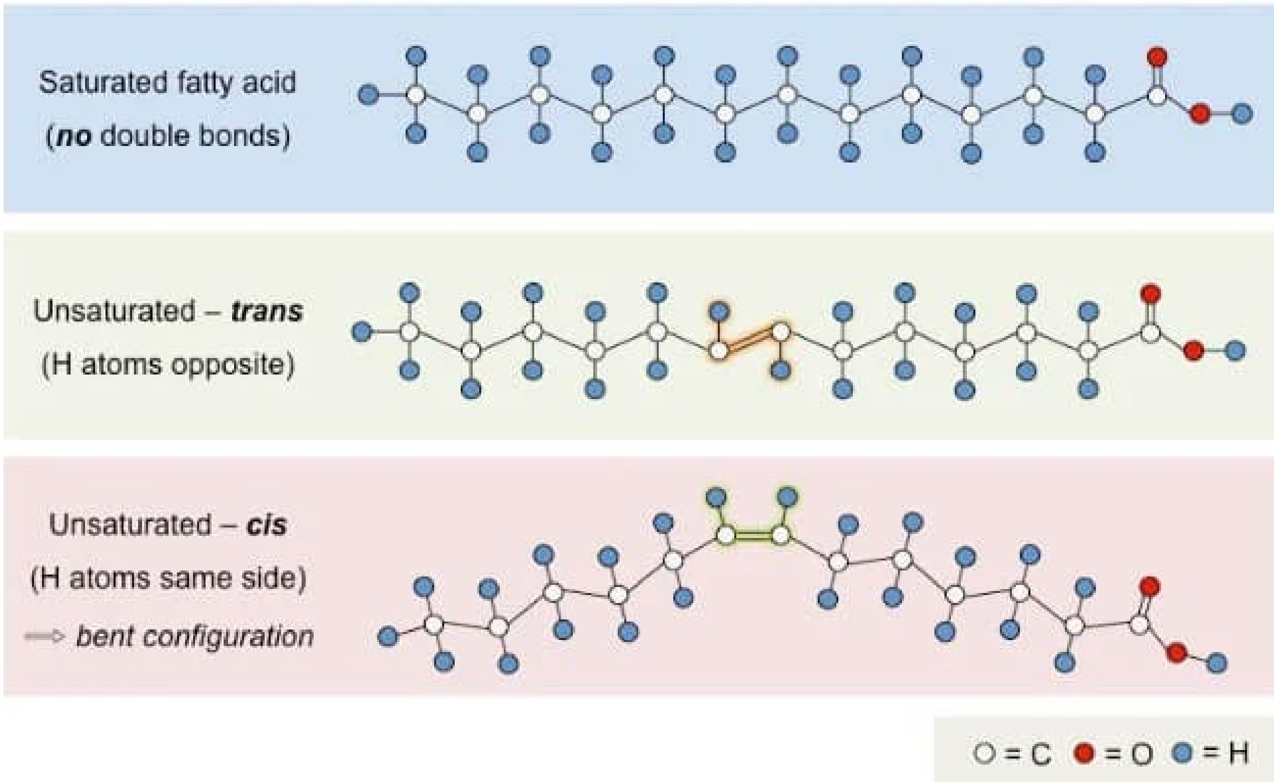
Physical properties of fat



(b) Hard fat (saturated): Fatty acids with single bonds between all carbon pairs

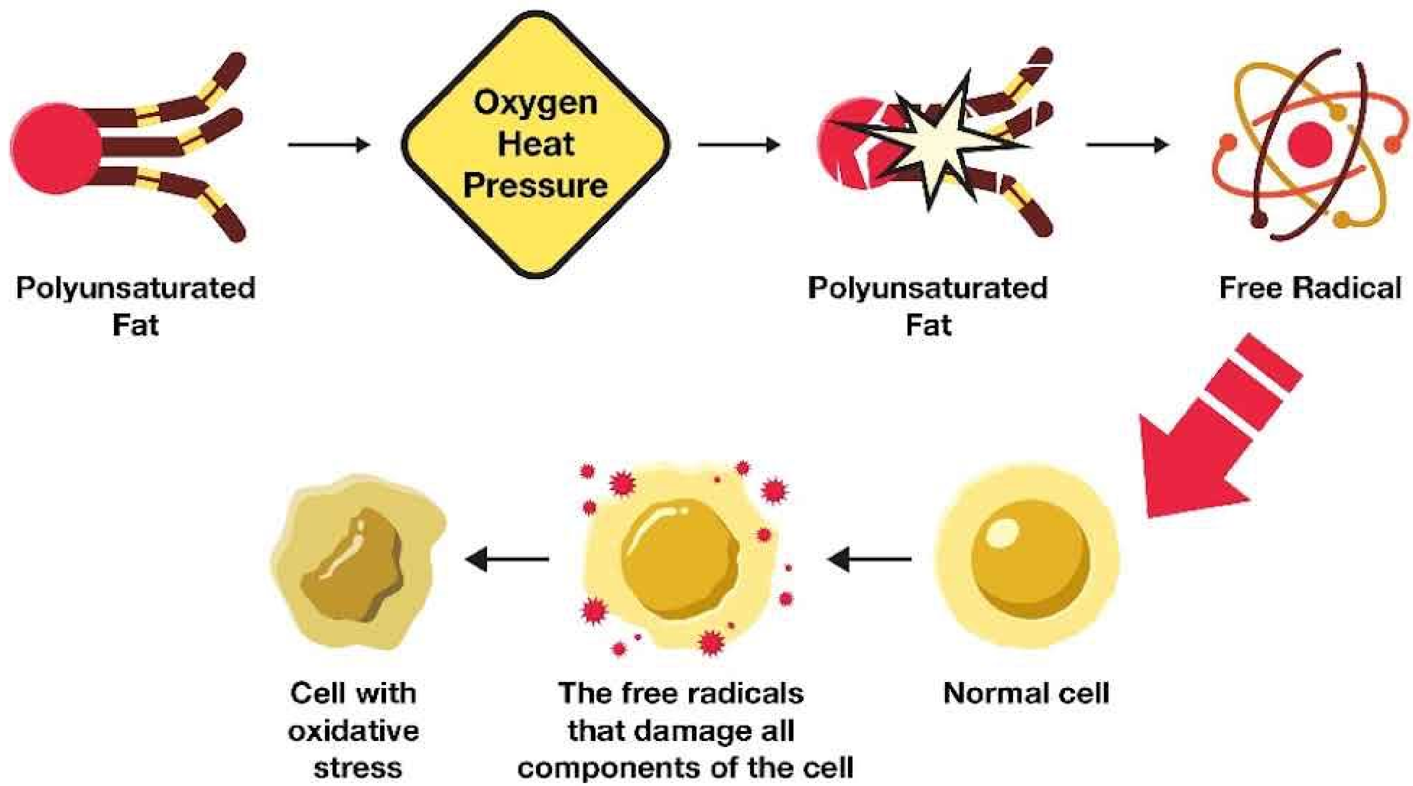
(c) Oil (unsaturated): Fatty acids that contain double bonds between one or more pairs of carbon atoms

Differences Between Saturated and Unsaturated fatty acids



https://microbenotes.com/saturated-vs-unsaturated-fatty-acids/

Polyunsaturated fatty acids easily are prone to be oxidazed



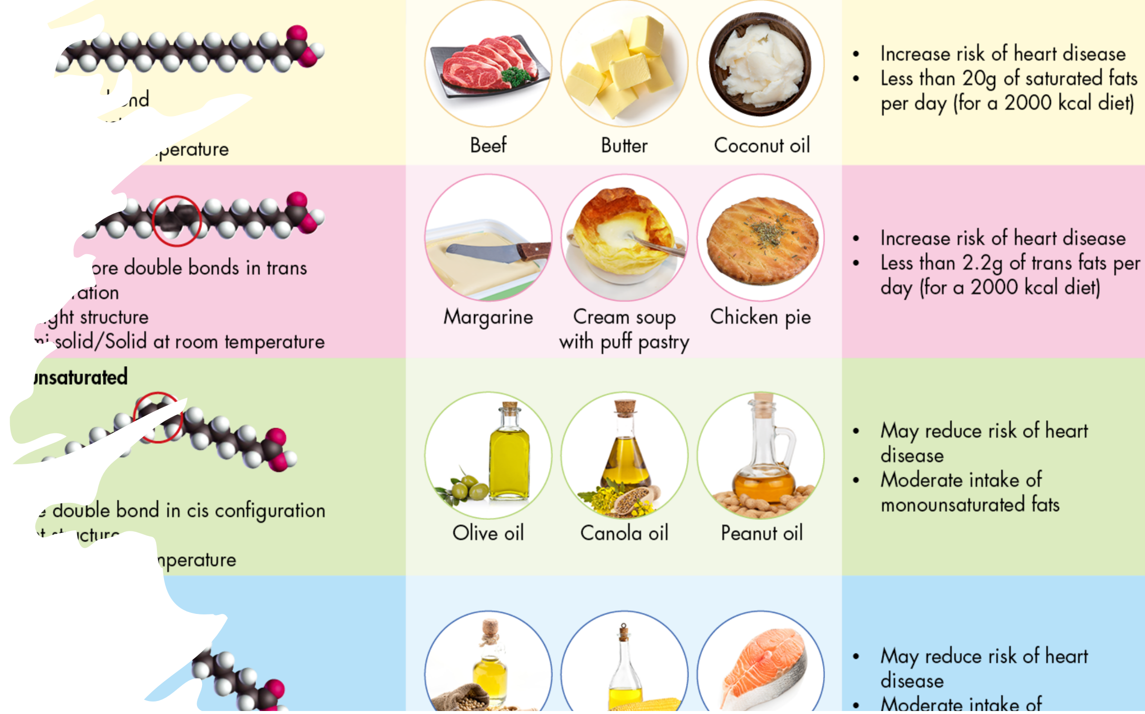
(Mercola y D'Adamo, 2023)

FISH OIL

Fatty Acid	Diet
	FO
C12:0	6.36
C14:0	6.10
C16:0	16.62
C18:0	2.76
Total saturated fatty acids	31.8
C16:1n-7	1.68
C18:1n-9	17.7
C18:1n-7	1.23
C20:1n-9	1.21
Total monounsaturated fatty acids	21.8
C18:2n-6	31.5
C18:3n-3	4.45
C18:4 n-3	2.16
C20:5n-3	3.39
C22:5n-3	0.92
C22:6n-3	4.00
Total polyunsaturated fatty acids PUFA	46.4
n-9	18.9
n-6	32.8
n-3	14.9
n-6/n-3 ratio	2.20

[1] ND = not detected.

How to choose an oil source to substitute the fish oil?



Fatty acids from different sources

feed formulations

Oils/fats	SFA	MUFA	LA	ALA	EPA	DHA	n-6 PUFA	n-3 PUFA	n-3/n-6 ratio
Fish oils									
Anchovy oil	28.8	24.9	1.2	0.8	17.0	8.8	1.3	31.2	24.0
Capelin oil	20.0	61.7	1.7	0.4	4.6	3.0	1.8	12.2	6.8
Menhaden oil	30.5	24.8	1.3	0.3	11.0	9.1	1.5	25.1	16.7
Herring oil	20.0	56.4	1.1	0.6	8.4	4.9	1.4	17.8	12.7
Cod liver oil	19.4	46.0	1.4	0.6	11.2	12.6	3.0	27.0	9.0
Vegetable oils									
Crude palm oil	48.8	37.0	9.1	0.2	-	-	9.1	0.2	0.0
Soybean oil	14.2	23.2	51.0	6.8	-	-	51.0	6.8	0.1
Canola oil	4.6	62.3	20.2	12.0	-	-	20.2	12.0	0.6
Sunflower oil	10.4	19.5	65.7	-	-	-	65.7	0.0	0.0
Cottonseed oil	45.3	17.8	51.5	0.2	-	-	51.5	0.2	0.0
Groundnut oil	11.8	46.2	32.0	-	-	-	32.0	0.0	0.0
Corn oil	12.7	24.2	58.0	0.7	-	-	58.0	0.7	0.0
Linseed oil	9.4	20.2	12.7	53.3	-	-	12.7	53.3	4.2
Animal fats									
Pork lard	38.6	44.0	10.2	1.0	-	-	10.2	1.0	0.1
Poultry fat	28.5	43.1	19.5	1.0	-	-	19.5	1.0	0.0
Beef tallow	47.5	40.5	3.1	0.6	-	-	3.1	0.6	0.2

Data compiled from National Research Council, 1993; Gunstone et. al., 1994; Hertrampf and Piedad-Pascual, 2000
ALA, a-linolenic acid, 18:3 n-3; DHA, docosahexaenoic acid, 22:6 n-3; EPA, eicosapentaenoic acid, 20:5 n-3; LA, linoleic acid, 18:2 n-6; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

All fat/lipid sources contain a mixture of fatty acids

?

Linoleic acid and plant sources

Table 2. Most commonly consumed cooking oils and percentages of LA content.

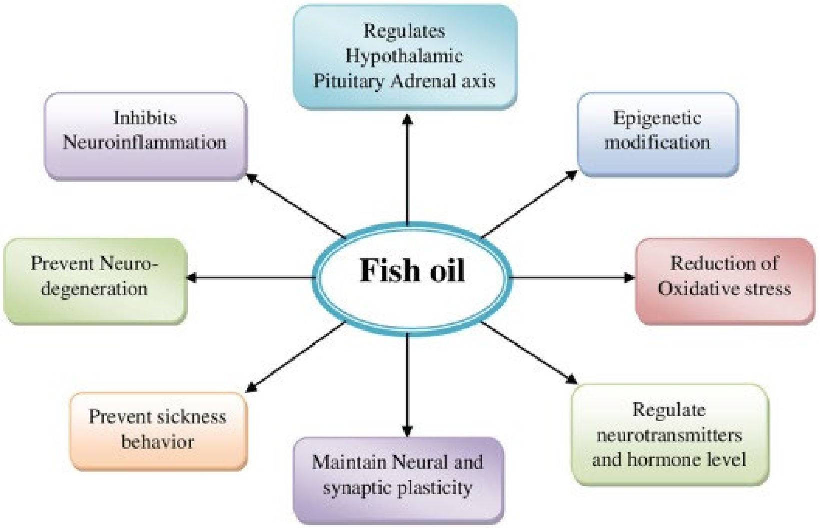
COOKING OILS	% LINOLEIC ACID (LA) AVERAGE VALUE (RANGE IN PARENTHESES)
SAFFLOWER OIL	70%
GRAPE SEED OIL	70%
SUNFLOWER OIL	68%
CORN OIL	54%
COTTONSEED OIL	52%
SOYBEAN OIL	51%
RICE BRAN OIL	33%
PEANUT OIL	32%
CANOLA OIL	19%
OLIVE OIL	10% (3–27%)
AVOCADO OIL	10%
LARD	10%
PALM OIL	10%
TALLOW (CAFO)	3%
GHEE/BUTTER (CAFO)	2%
COCONUT OIL	2%
TALLOW (GRASS FED)	1%
BUTTER (GRASS FED)	1%

Red—high linoleic acid; yellow—moderate linoleic acid; green—low linoleic acid.

(Mercola y D'Adamo, 2023)

Oils and fats according to the price of fish oil

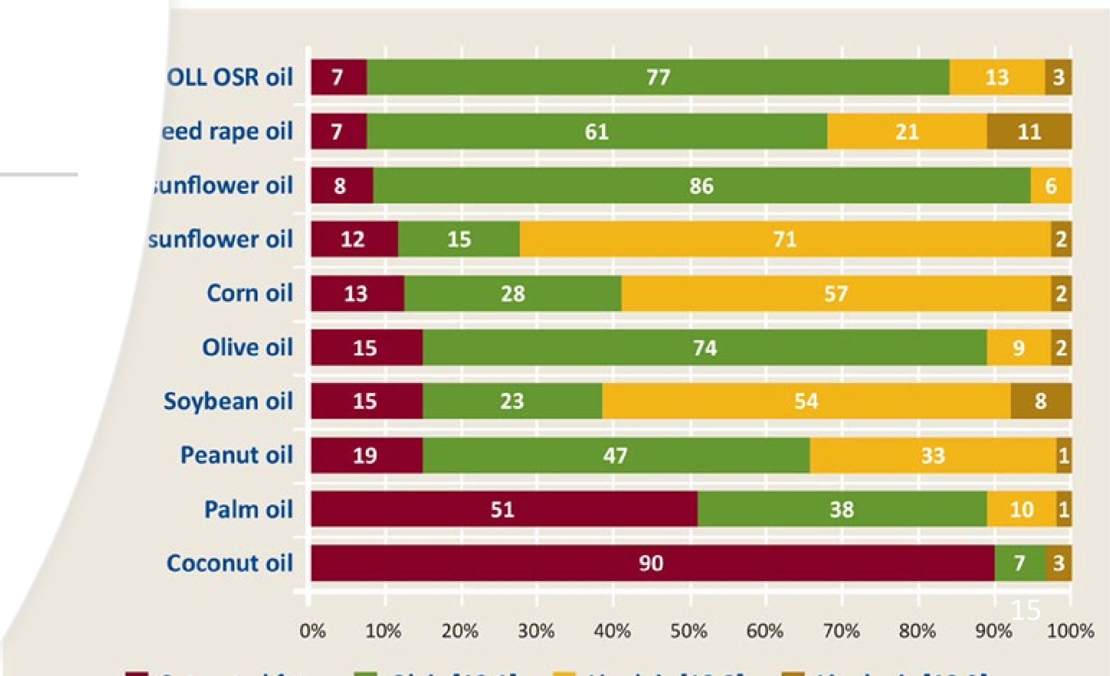
Fish oil properties



Fatty Acid	FO
C12:0	6.36
C14:0	6.10
C16:0	16.62
C18:0	2.76
Total saturated fatty acids	31.8
C16:1n-7	1.68
C18:1n-9	17.7
C18:1n-7	1.23
C20:1n-9	1.21
Total monounsaturated fatty acids	21.8
C18:2n-6	31.5
C18:3n-3	4.45
C18:4 n-3	2.16
C20:5n-3	3.39
C22:5n-3	0.92
C22:6n-3	4.00
Total polyunsaturated fatty acids PUFA	46.4
n-9	18.9
n-6	32.8
n-3	14.9
n-6/n-3 ratio	2.20

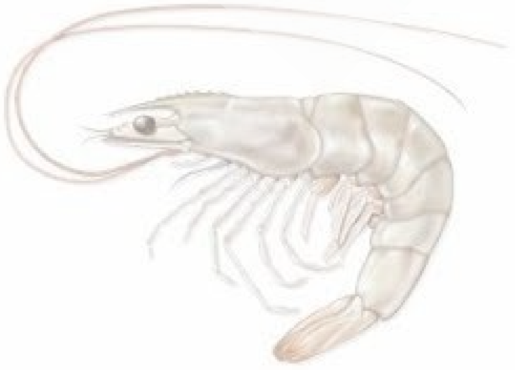
[1] ND = not detecte

Formulating to ideal fatty acid profile?



Fatty acid profiles from fish oil and the fat mixture containing 71% poultry fat, 25% Kernel, and 4 % DHA nature (mix of DHA and EPA)

	Oil sources	
Fatty acid	Fish oil	Fat mixture
08:00	ND	1.2
10:00	ND	1.4
12:0	ND	18.3
14:0	10.4	7.3
16:0	27.9	18.7
18:0	6.0	6.3
Σ SFAs	**44.3**	**53.2**
16:1n7	10.8	5.6
18:1n7	3.3	ND
18:1n9	14.2	32.5
Σ MUFAs	**15.3**	**38.1**
18:2n6	3.5	2.6
18:3n3	1.3	0.6
20:4n6	1.2	ND
20:5n3	5.6	1.2
22:5n3	0.6	ND
22:6n3	4.8	1.6
Σ n3	**12.3**	**3.4**
Σ n6	**4.7**	**2.6**



Fat mixture vs Fish oil for shrimp and tilapia

Arambul et al., 2024

Experiment 1

fat mixture vs fish oil

for the white leg shrimp *Litopenaeus vannamei*

E. Arambul-Muñoz et al.

Table 1
Ingredients and proximate composition (g Kg^{-1} on a dry matter basis, DM) of four isoproteic and isolipidic diets formulated to contain different fat mixture (poultry fat 71%; palm kernel fat 25%; DHA concentrate 4%) levels replacing fish oil fed to shrimp *Litopenaeus vannamei* for 7 weeks.

Ingredients, g Kg^{-1}, DM	Dietary Fat mixture levels			
	Control	L-Mix	M-Mix	H-Mix
Fishmeal[a] (defatted)	5.00	5.00	5.00	5.00
Poultry by-product meal[b] (defatted)	25.00	25.00	25.00	25.00
Soybean 65%[c]	10.00	10.00	10.00	10.00
Wheat flour[d]	19.00	19.00	19.00	19.00
Gelatin[e]	7.00	7.00	7.00	7.00
Fish oil[f]	5.00	3.35	1.68	0.00
Fat mixture[g]	0.00	1.65	3.32	5.00
Corn starch[h]	24.00	24.00	24.00	24.00
Methionin[i]	1.00	1.00	1.00	1.00
Vitamin and mineral mixture[j]	2.50	2.50	2.50	2.50
Vitamin C[k]	0.10	0.10	0.10	0.10
Soy lecithin[l]	1.29	1.29	1.29	1.29
Sodium benzoate	0.10	0.10	0.10	0.10
BHT[l]	0.01	0.01	0.01	0.01
Proximate composition (% dry matters basis) *				
Crude Protein (%)	37.6	37.7	37.9	37.6
Crude Lipid (%)	7.4	7.5	7.5	7.5
Ash (%)	7.2	7.3	7.2	7.3
NFE	50.8	50.8	50.8	50.8
EPA	0.05	0.04	0.02	0.00
DHA	0.06	0.04	0.02	0.01

Arambul et al., 2024

Experiment 1

fat mixture vs fish oil

Fatty acid profile

Table 3
Fatty acid composition (%) of formulated diets containing different inclusion of Fat Mixture (poultry fat 71%; palm kernel fat 25%; DHA concentrate 4%) in replacement of Fish oil.

	Dietary treatments			
Fatty acid	Control	L-Mix	M-Mix	H-Mix
8:0	0	0.39	0.72	1.03
10:0	0	0.61	0.78	1.08
12:0	0	8.07	12.07	16.23
14:0	6.94	7.18	7.42	7.59
16:0	22.428	20.01	18.18	17.49
18:0	4.87	4.97	6.45	7.19
∑SFA	**34.238**	**41.23**	**45.62**	**50.61**
16:1	8.25	6.04	5.42	5.17
18:1n9	13.674	25.4	30.73	31.47
20:1n9	1.401	1.134	0.687	0.54
∑MUFA	**23.325**	**32.574**	**36.837**	**37.18**
18:2n6	14.21	12.08	8.17	5.91
20:4n6	1.97	0.85	0.54	0.21
∑PUFAn6	**16.18**	**12.93**	**8.71**	**6.12**
18:3n3	3.45	0.72	0.21	0.06
20:5n3	14.18	2.35	1.16	0.31
22:6n3	10.45	7.63	5.24	3.12
∑PUFAn3	**24.63**	**9.98**	**6.4**	**3.43**
∑PUFAs	**40.81**	**22.91**	**15.11**	**9.55**
Others	1.2	3.16	2.15	2.64

L-Mix (low inclusion), M-Mix (medium inclusion), H-Mix (high inclusion). ∑SFA, ∑MUFA, ∑PUFA, are the sum of saturated, monounsaturated, polyunsaturated respectively.

Arambul et al., 2024

Experiment 1

Results

Arambul et al., 2024

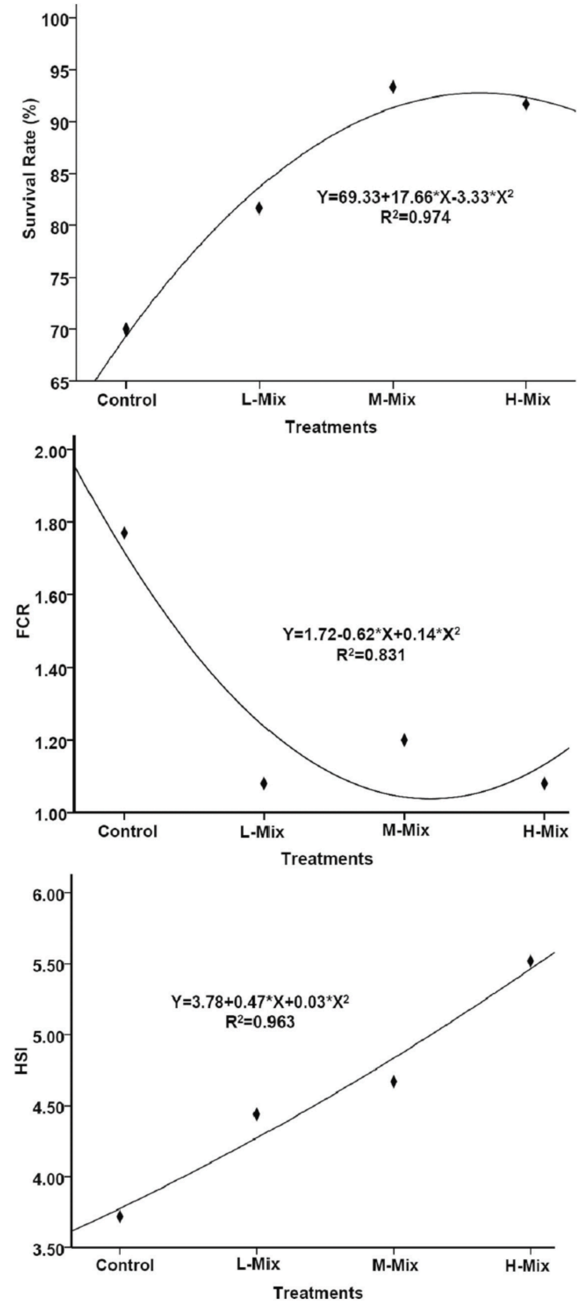


Fig. 2. Polynomial (quadratic) regression analysis among levels of fat mixture (poultry fat 71%; palm kernel fat 25%; DHA concentrate 4%) in the diet on the survival rate (SR %), feed conversion rate (FCR), and hepatosomatic index (HSI). The lines indicate the best-fit polynomial regression equations and the R^2 values indicate the power of the model. Treatments: 0 (Control), 1.65 (L-Mix), 3.32 (M-Mix), and 5% (H-Mix) in replacement of Fish oil.

Experiment 1

Results

Table 4
Overall performance of white leg juveniles of *Litopenaeus vannamei*, fed diets containing four different levels of a Fat Mixture (poultry fat 71%; palm kernel fat 25%; DHA concentrate 4%); 0, 1.65, 3.32, and 5% in replacement of Fish oil (FO) for 7 weeks.

Index	TREATMENT				
	Control	L-Mix	M-Mix	H-Mix	*P* value
IBW (g)	2.21 ± 0.05	2.23 ± 0.02	2.25 ± 0.01	2.23 ± 0.03	0.925
FBW(g)	4.85 ± 0.76	5.59 ± 0.12	5.08 ± 0.24	5.43 ± 0.19	0.608
WG (g)	2.64 ± 0.79	3.35 ± 0.11	2.83 ± 0.25	3.20 ± 0.22	0.647
RWG (%)	120.55 ± 37.82	150.2 ± 4.6	126.3 ± 11.5	144.2 ± 11.6	0.716
SGR (%)	1.55 ± 0.37	1.9 ± 0.04	1.7 ± 0.10	1.8 ± 0.10	0.668
FCR	1.77 ± 0.67	1.08 ± 0.07	1.20 ± 0.18	1.08 ± 0.17	0.050
FI (BW % day^{-1})	5.49 ± 0.40	5.37 ± 0.20	6.0 ± 0.53	5.37 ± 0.50	0.698
HSI (%)	3.72 ± 0.33^{b}	4.4 ± 0.08^{ab}	4.7 ± 0.57^{ab}	5.5 ± 0.31^{a}	0.048
TGC	0.28 ± 0.07	0.34 ± 0.01	0.30 ± 0.02	0.33 ± 0.02	0.659
SR (%)	70 ± 7.63^{b}	81.66 ± 6^{ab}	93.33 ± 1.7^{a}	91.66 ± 1.7^{a}	0.037

L-Mix (low inclusion), M-Mix (medium inclusion), H-Mix (high inclusion). Mean ± EE values in each row with different superscripts were significantly different ($P < 0.05$, Tukey's test). IBW = Initial body weight, FBW = final body weight, WG = weight gained, RWG = relative weight gained, SGR = specific growth rate, FCR = conversion ratio, HSI = hepatosomatic index, TGC = thermal growth rate and SR = survival rate.

Arambul et al., 2024

Experiment 2

fat mixture vs fish oil

for the tilapia

Oreochromis niloticus

Table 1. Ingredients and proximate composition (g Kg^{-1} on a dry matter basis, DM) of four isoproteic and isolipidic diets formulated to contain different fat mixture (Poultry fat 71%; Kernel fat 25%; DHA concentrate 4%) levels replacing Fish oil fed to fish *Oreochromis niloticus* for 6 weeks.

Ingredients, g Kg^{-1}, DM	Dietary Fat mixture levels (%)			
	Control	**Low-Mix**	**Med-Mix**	**High-Mix**
Fish meal[a]	5	5	5	5
Poultry by-product meal[b]	25	25	25	25
Soybean 65% ADM[c]	10	10	10	10
Wheat flour[d]	19	19	19	19
Gelatin[e]	7	7	7	7
Fish oil[f]	5	3.35	1.68	0
Fat mixture[g]	0	1.65	3.32	5
Maizena™ [h](corn starch)	24	24	24	24
Metionine[i]	1	1	1	1
Rovimix[j]	2.5	2.5	2.5	2.5
Stay C[k]	0.10	0.10	0.10	0.10
Phospholipids[l]	1.29	1.29	1.29	1.29
Sodium bensoato[m]	0.10	0.10	0.10	0.10
BHT[m]	0.01	0.01	0.01	0.01
Proximate composition (% dry matters basis)				
Crude Protein (%)	37.6	37.4	37.3	37.6
Crude Lipid (%)	8.1	8.1	8	8
Ash (%)	7	7	7	7
NFE	50.8	50.8	50.8	50.8
EPA	0.05	0.04	0.02	0
DHA	0.06	0.04	0.02	0.01

Arambul et al., 2024

Experiment 2

Results

Overall performance of tilapias fed different levels of fat mixture in replacement of fish oil

Index	Treatment				
	Control	Low-Mix	Med-Mix	High-MixFBW	*P valu*
IBW (g)	6.03 ± 0.06	6 ± 0.10	6.09 ± 0.09	6.04 ± 0.07	0.917
FBW(g)	82.07 ± 0.74	84.32 ± 0.70	83.72 ± 0.83	83.64 ± 2.28	0.392
WG (g)	76.04 ± 0.74	78.31 ± 0.79	77.62 ± 0.79	77.60 ± 2.22	0.50
SGR (%)	3.89 ± 0.02	3.94 ± 0.03	3.91 ± 0.02	3.92 ± 0.03	0.687
FCR	0.61 ± 0.01	0.59 ± 0.01	0.59 ± 0.01	0.59 ± 0.01	0.147
HI (%)	2.07 ± 0.15	2.04 ± 0.18	2.18 ± 0.12	2.46 ± 0.03	0.085
VSI	10.30 ± 0.33	10.99 ± 0.10	11.93 ± 0.29	11.98 ± 0.77	0.083
TGC	1.36 ± 0.01	1.38 ± 0.01	1.37 ± 0.01	1.38 ± 0.01	0.63
Sv (%)	98.33 ± 1.66	96.67 ± 1.66	96.67 ± 1.66	96.67 ± 1.66	0.815

Arambul et al., 2024

Experiment 3 “Higher C12”

Ingredients and proximate composition (g Kg^{-1} on a dry matter basis, DM) of four isoproteic and isolipidic diets formulated to contain different fat mixture (50% palm kern fat; 25% poultry fat; 25% beef tallow) levels replacing fish oil for *Oreochromis niloticus*.

L-FM (low inclusion), M-FM (medium inclusion), H-FM (high inclusion).

INGREDIENTS, G KG^{-1}, DM	DIETARY TREATMENTS			
	Control	Low	Medium	High
Poultry by-product meal[a]	220	220	220	220
Bovine by-product meal[a]	70	70	70	70
Soybean 43%[b]	140	140	140	140
Wheat flour[c]	125	123	122.2	121.5
Maizena™ (corn starch)[d]	210	210	210	210
Gelatin[e]	70	70	70	70
Corn gluten[f]	50	50	50	50
Fish oil[g]	52	33.5	16.8	0
Fat mixture[h]	0	15.5	31	46.5
Taurine[i]	10	10	10	10
Metionine[i]	10	10	10	10
Vitamin and mineral mixture[j]	25	25	25	25
Vitamin C[j]	1	1	1	1
Phospholipids[k]	12.9	12.9	12.9	12.9
Cholesterol[l]	3	3	3	3
DHA-Nature™ [m]	0	5	7	9
Sodium benzoate[n]	1	1	1	1
BHT[o]	0.1	0.1	0.1	0.1
Proximate composition (%, DM)				
Crude protein	34.0	34.3	34.4	33.4
Crude lipid	7.8	7.6	7.7	7.5
Ash	7.9	8.0	7.8	7.8
NFE	50.2	50.0	50.1	51.3

Unpublished results

Experiment 3 Fatty acids from diets with higher C12

Fatty acid composition (%) of formulated diets containing different inclusion of fat mixture (palm kernel fat 50%; poultry fat 25%; beef tallow 25%) in replacement of fish oil.

L-FM (low inclusion), M-FM (medium inclusion), H-FM (high inclusion).

Unpublished results

	Dietary treatments			
Fatty acid	Control	L-FM	M-FM	H-FM
12:0	0.12	6.41	10.86	14.34
14:0	5.32	6.83	6.97	7.65
15:0	0.02	0.02	0.03	0.03
16:0	20.97	19.44	19.16	19.12
18:0	5.46	5.99	7.19	8.32
22:0	0.61	0.51	0.36	0.18
∑SFA	32.5	39.2	44.57	49.64
14:1	0.17	0.26	0.24	0.55
15:1	0.16	0.25	0.2	0.42
16:1	6.14	4.7	3.26	2.23
18:1n9	23.46	22.3	24.3	25.48
20:1n9	1.1	0.94	0.74	0.4
∑MUFA	31.03	28.45	28.74	29.08
18:2n6	19.4	18.46	17.34	16.79
18:3n6	0.25	0.26	0.24	0.12
20:3n6	0.3	0.31	0.25	0.16
20:4n6	0.17	0.23	0.17	0.22
∑PUFAn6	20.12	19.26	18	17.29
18:3n3	2.73	2.49	2.08	1.57
20:3n3	1.44	1.11	0.76	0.34
20:5n3	6.97	4.84	2.42	0.23
22:6n3	4.73	4.21	3.06	1.8
∑PUFAn3	15.87	12.65	8.32	3.94
∑PUFAs	35.99	31.91	26.32	21.23
Others	0.47	0.45	0.38	0.24
Total	100	100	100	100

Results
Experiment 3

Higher C12

Biological indices in tilapia (*Oreochromis niloticus*) juveniles after being fed for eight weeks with diets containing different fat mixture (palm kern fat 50%; poultry fat 25%; beef tallow 25%) levels in replacement of fish oil (FO).

- L-FM (low inclusion), M-FM (medium inclusion), H-FM (high inclusion). Mean ± SD values in each row with different superscripts were significantly different ($P < 0.05$, Tukey's test)..

Biological indices	Dietary treatment				
	Control	L-FM	M-FM	H-FM	P value
IBW (g)	6.33 ± 0.08	6.34 ± 0.03	6.34 ± 0.12	6.20 ± 0.10	
FBW (g)	106.05 ± 12.50	109.54 ± 5.51	107.95 ± 8.0	108.73 ± 1.08	0.826
WG (g)	99.71 ± 12.44	103.20 ± 5.52	101.61 ± 7.94	102.53 ± 1.16	0.826
RWG (%)	1573 ± 180	1629 ± 89	1602 ± 113	1654 ± 42	0.838
SGR (%)	5.02 ± 0.19	5.09 ± 0.09	5.06 ± 0.12	5.11 ± 0.04	0.838
FCR	1.08 ± 0.06	1.03 ± 0.05	1.09 ± 0.02	1.08 ± 0.01	0.764
K	2.03 ± 0.16	2.12 ± 0.20	2.08 ± 0.13	2.09 ± 0.06	0.905
HSI (%)	3.11 ± 0.61	3.21 ± 0.53	3.22 ± 0.19	3.72 ± 0.31	0.380
VSI (%)	11.06 ± 1.02	10.71 ± 0.45	10.78 ± 0.95	11.77 ± 0.66	0.406
TGC (%)	1.86 ± 0.11	1.90 ± 0.05	1.88 ± 0.07	1.90 ± 0.02	0.838
Sv (%)	93.33 ± 2.89	98.33 ± 2.89	96.67 ± 5.77	96.67 ± 2.89	0.400

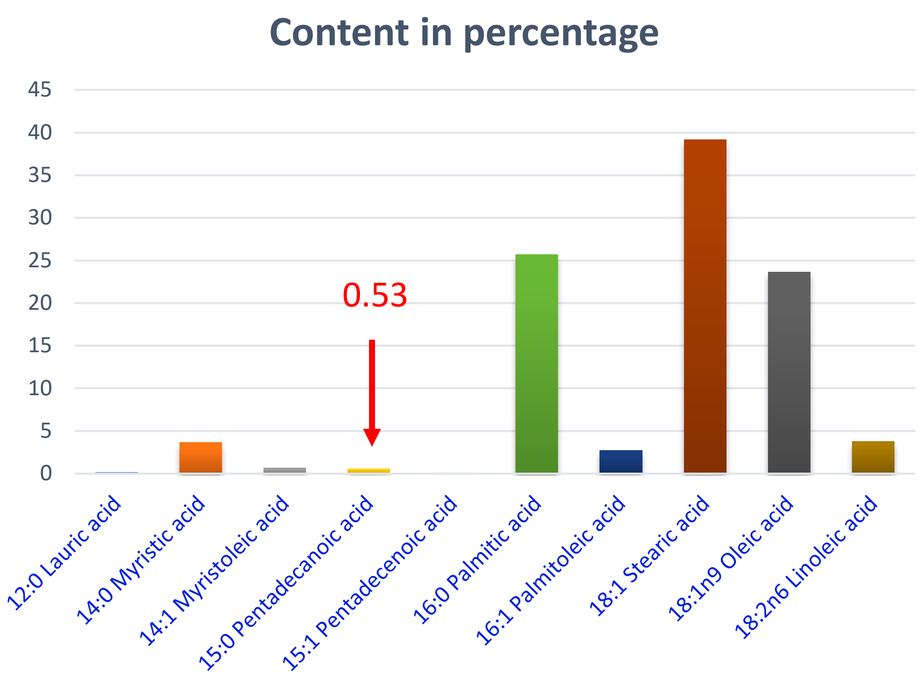
IBW = Initial body weight, FBW = final body weight, WG = weight gained, RWG = relative weight gained, SGR = specific growth rate, FCR = conversion ratio, K= condition factor, HSI = hepatosomatic index, VSI= viscerosomatic index, TGC = thermal growth rate and Sv = survival rate

Unpublished results

Fat from Bovine (tallow)

- Special case since most nutrients comes from the Ruminal microorganisms
- Most animal fats are made with carbon in pairs
- Bovine fat has a fatty acid with C15:0 fatty acid (pentadecanoic acid)
- Is synthesized by the bacteria flora in the rumen
- C15 is considered essential for long-term health
- Cell repairing mechanism

Fat from Bovine (tallow) Fatty acid profile



Experiment 3
Bovine fat
C15

Ingredients and approximate composition (g Kg-1 on a dry matter basis, DM) of four isoprotein and isolipid diets formulated to contain different levels of beef tallow as a substitute for soybean oil for *Oreochromis niloticus.*

Ungoing experiment

Ingredients, g Kg-1, DM	Dietary treatments			
	Control	L-BT	M-BT	H-BT
Soybean 49%[a]	450	450	450	450
Bovine by-product meal[b]	100	100	100	100
Maizena™ [c]	113.9	114	114	113
Corn gluten[d]	100	100	100	100
Gelatin[e]	100	100	100	100
Soybean oil[f]	65	43.3	21.6	0
Beef tallow[g]	0	21.6	43.3	65
Vitamin and mineral mixture[h]	30	30	30	30
DHA-Nature™ [i]	30	30	30	30
Metionine[j]	5	5	5	5
Vitamin C[h]	5	5	5	5
Sodium benzoate[k]	1	1	1	1
BHT[l]	0.1	0.1	0.1	0.1
Proximate composition (%, DM)				
Crude protein	39.8	39.8	40	39.7
Crude lipid	9.1	8.8	8.9	9.1
Ash	9.6	10.1	9.4	10.1
NFE	41.5	41.3	41.7	41.1

Experiment 3
Bovine fat
C15

Fatty acid composition (%) of formulated diets containing different inclusion of beef tallow in replacement of soybean oil.

L-BT= low beef tallow; M-BT= medium beef tallow; H-BT= high beef tallow.

Ungoing experiment

Fatty acid	Dietary treatments			
	Control	L-BT	M-BT	H-BT
10:0	4.44	2.76	3.91	2.95
12:0	0.47	0.16	0.18	0.16
14:0	5.08	4.79	5.62	6.3
15:0	0.12	0.36	0.37	0.4
16:0	13.67	14.22	17.41	21.01
18:0	3.95	5	9.98	15.78
20:0	0.39	0.76	0.57	0.45
∑SFA	28.12	28.05	38.04	47.13
14:1	0.13	0.23	0.4	0.42
15:1	0.08	0.14	0.11	0.05
16:1	0.75	1.03	1.48	1.87
18:1n9	18.29	28.51	29.48	31.99
20:1n9	0.20	0.38	0.34	0.37
∑MUFA	19.45	30.29	31.81	34.7
18:2n6	43.26	30.68	22.41	11.65
20:4n6	0.11	0.43	0.23	0.09
∑PUFAn6	43.37	31.11	22.64	11.74
18:3n3	4.93	3.86	2.55	1.16
20:3n3	0.11	0.29	0.21	0.17
20:5n3	0.32	0.67	0.39	0.2
22:6n3	3.72	5.72	4.36	4.88
∑PUFAn3	9.08	10.54	7.51	6.41
∑PUFAs	52.45	41.65	30.15	18.15
Total	100	100	100	100

Experiment 3
Results
Bovine fat
C15

Biological indices in tilapia (*Oreochromis niloticus*) juveniles after being fed for 49 days with diets containing different beef tallow levels in replacement of soybean oil.

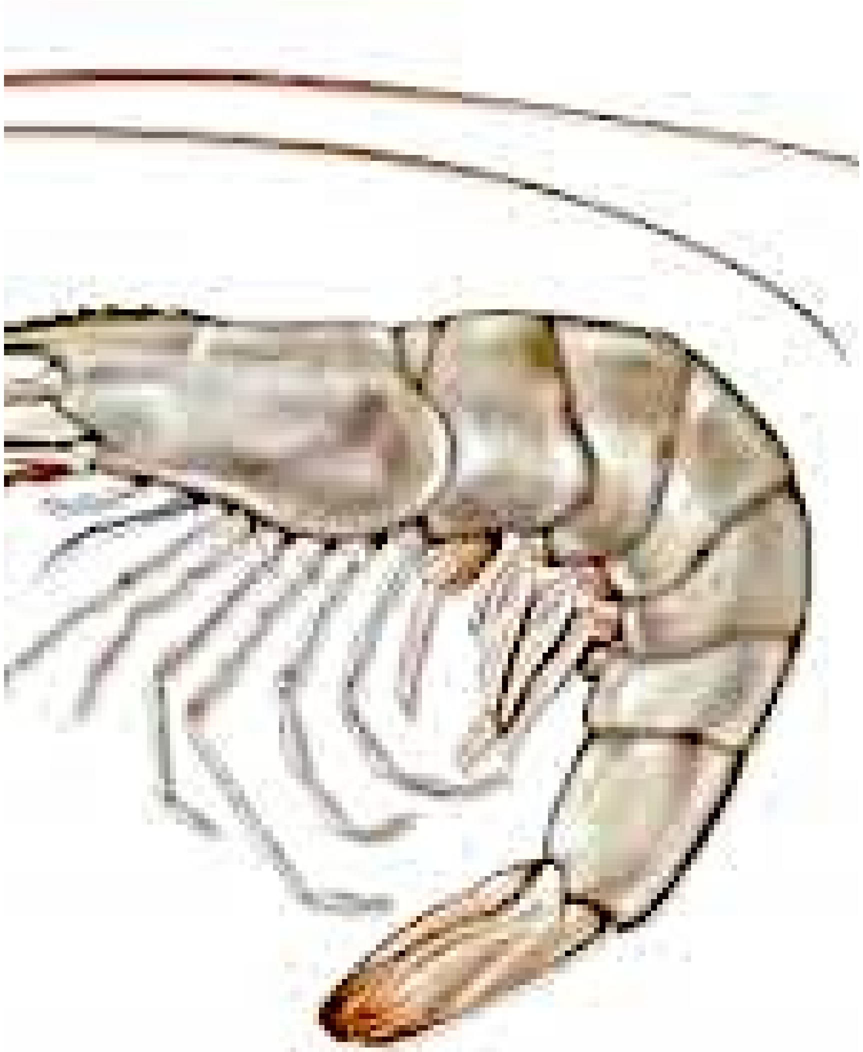
	Dietary treatment				
	Control	L-BT	M-BT	H-BT	P value
IBW (g)	2.12 ± 0.0	2.12 ± 0.0	2.12 ± 0.0	2.12 ± 0.0	
FBW (g)	12.78 ± 8.32	19.97 ± 2.26	9.71 ± 2.04	17.13 ± 1.33	0.089
WG (g)	10.66 ± 8.32	17.85 ± 2.26	7.59 ± 2.04	15.01 ± 1.33	0.089
RWG (%)	503 ± 393	842 ± 106	358 ± 96	708 ± 63	0.089
SGR (%)	3.39 ± 1.27	4.57 ± 0.22	3.07 ± 0.46	4.26 ± 0.16	0.086
FCR	1.52 ± 1.14	0.64 ± 0.38	1.39 ± 0.98	0.71 ± 0.15	0.340
K	1.81 ± 0.18	1.89 ± 0.01	1.72 ± 0.09	1.95 ± 0.12	0.243
HSI (%)	1.99 ± 0.38	1.88 ± 0.08	1.80 ± 0.39	2.18 ± 0.34	0.547
VSI (%)	10.47 ± 1.10	11.13 ± 0.50	9.36 ± 1.17	10.85 ± 0.71	0.168
TGC (%)	0.71 ± 0.35	1.02 ± 0.07	0.60 ± 0.11	0.93 ± 0.05	0.141
Sv (%)	73.68 ± 5.26	80.70 ± 21.27	78.95 ± 13.93	85.96 ± 6.08	0.522

Ungoing experiment

CONCLUSIONS

- With a mixture of poultry fat (71%) with Kernel (25%) and DHA (4%) it is possible to replace fish oil resulting in a better FCR despite growth was similar

- The linoleic acid is also decrease



CONCLUSIONS

- With a mixture of poultry fat (71%) with Kernel (25%) and DHA (4%) it is posible to replace fish oil without compromising the overall performance

- However, extra Kernel (C:12) failed to improve the overall performance

- The use of Bovine tallow is a promising alternative for aquaculture diets

Ongoing studies

- Investigating health parameters associated with beef tallow and awaiting gene expression data to assess lipid metabolism

- And liver histological studies

Thank You