Understanding the ways of utilisation of sustainable innovative tailor-made diets in farmed fish

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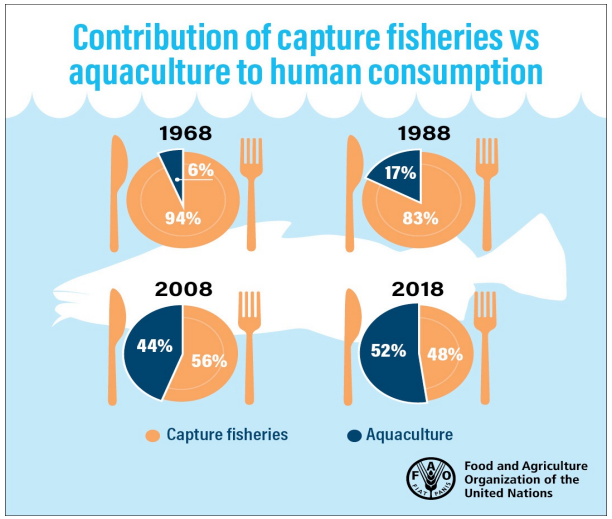
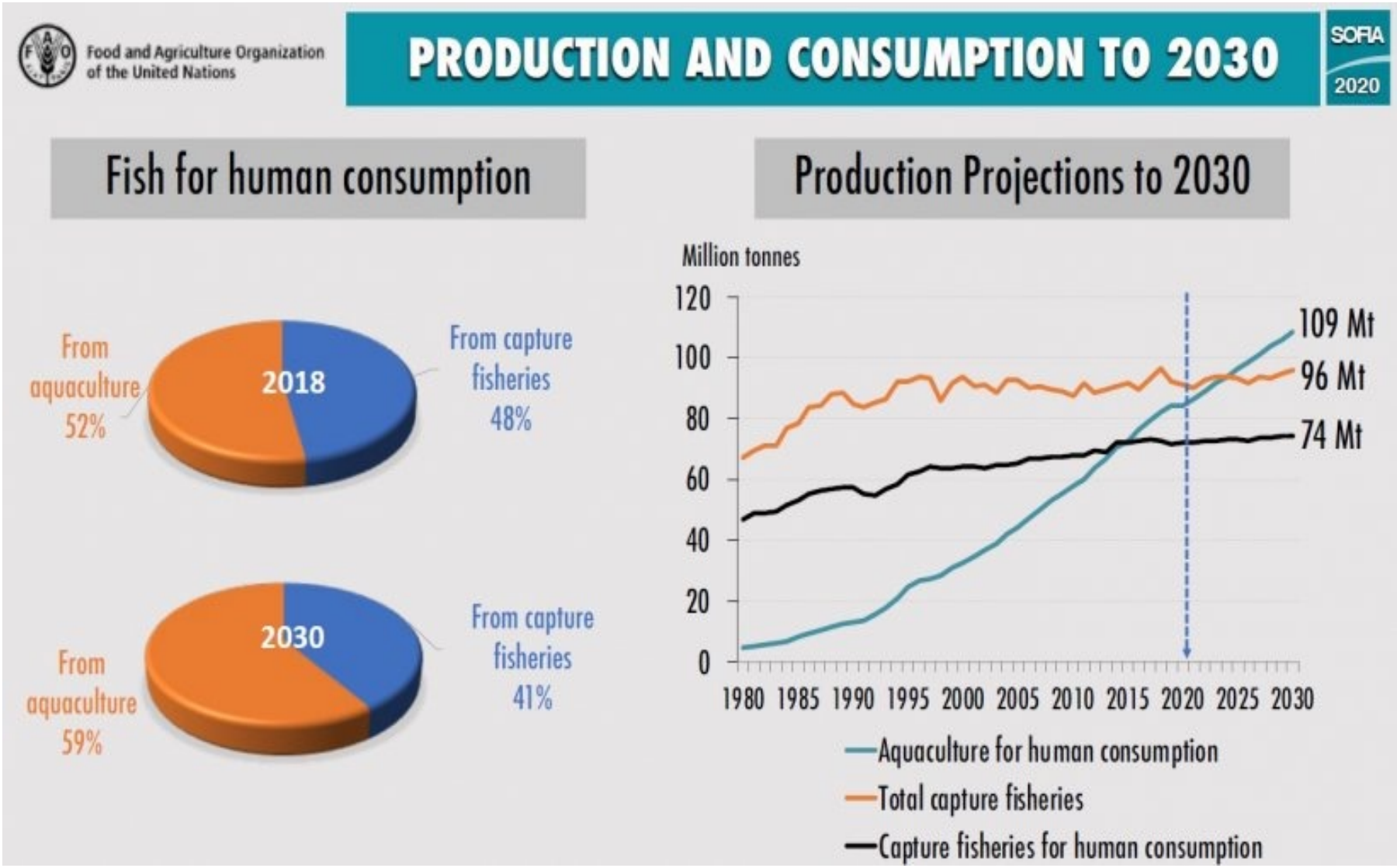
Aquaculture



AQUACULTURE IS THE FUTURE OF FOOD

By 2030, nearly two-thirds of all seafood produced for human consumption will come from aquaculture (World Bank).

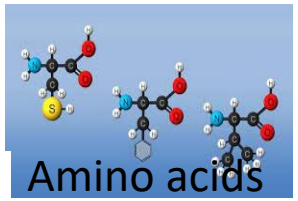


40Mt aquafeeds

Aquafeeds-Sourcing

essential nutrients

Vitamins, Minerals



Amino acids

AQUATIC ANIMAL PROTEIN MEALS & LIPIDS

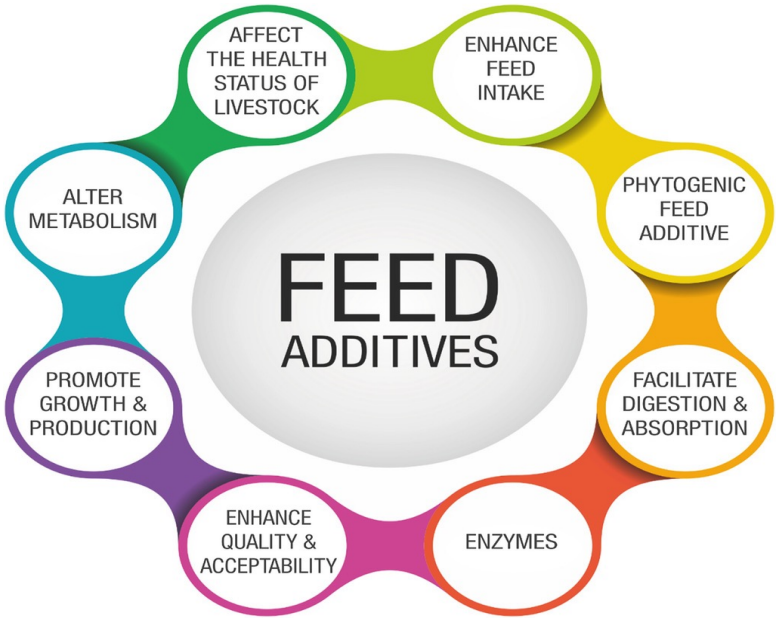
OILSEED MEALS, PULSES & OILS

40 essential nutrients

LAND ANIMAL PROTEIN MEALS & FATS

CEREALS INCLUDING BY-PRODUCT MEALS & OILS

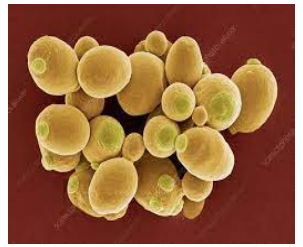
MICROBIAL FEED INGREDIENTS



Biotechnology

microalgae

Bacterial protein



yeast

Sustainable and resilient feed and feeding strategies

FutureEUAqua WP2 role is to coordinate the research activity and efforts to develop **innovative, species specific nutritionally adequate, tailor-made**, low ecological footprint organic and conventional diets and validate them in different fish production systems.

✔ The aim of WP2 is to demonstrate **sustainable and resilient nutritional solutions** for highest possible fish performances that would be safe and commercially available for the European aquaculture.

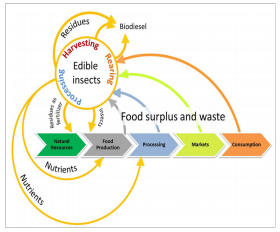
Design

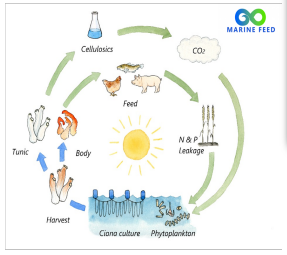
Select raw materials

FM and FO
Mineral and Vitamin premix
Novel ingredients

- *Bacterial protein*
- *Yeast meal*
- *Microalgae*
- *Insect meal*
- *Tunicate meal*
- *Fish meal trimmings*

1. Innovative raw material selection on circular economy principles

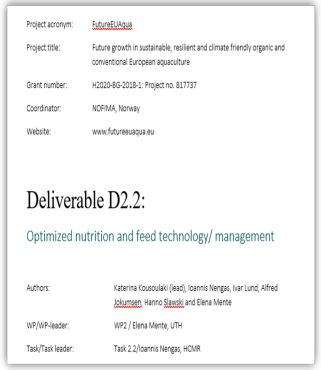


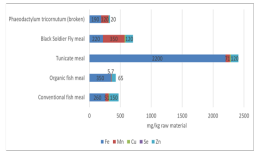


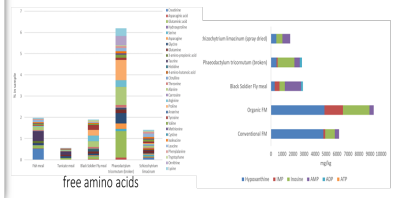
Design Feed formulation

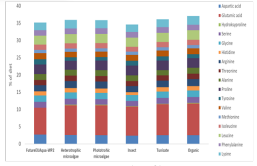
Produce diets
Commercially relevant
Safe
Low ecological footprint
Species specific nutritionally adequate

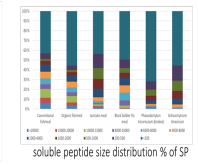
2. Chemical analysis of raw materials



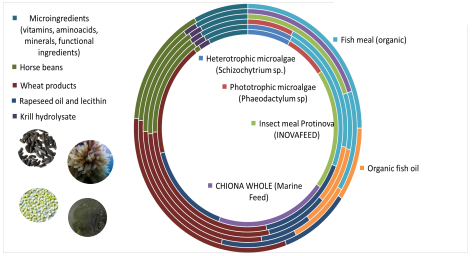








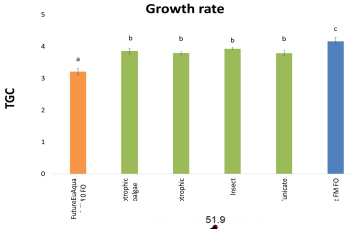
3. Feed formulation, production and analysis of diet chemical composition

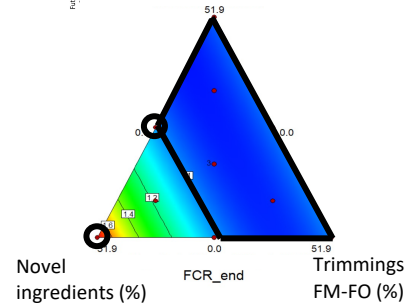


Test fish growth performance and evaluate

Growth performance
Health
Quality

4. Feeding trials in lab/small scale

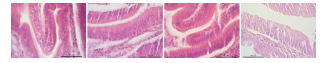




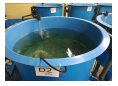
Validate the results in large scale trials

operational environments
Propose amendments to the organic legislation

5. Fish performance, physiology, health, welfare and product quality evaluation

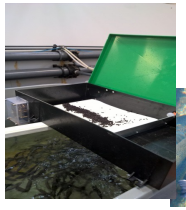


Feeding fish trials with FutureEUAqua novel aquafeeds



hcmr ΕΛΚΕΘΕ

Greece



Denmark

DTU

Nofima

Norway

European sea bass

NIREUS

AVRAMAR

IRIDA

1987 GALAXIDI MARINE FARM

Sea bream

IRIDA

KEFALONIA fisheries

Rainbow trout

ALLER AQUA

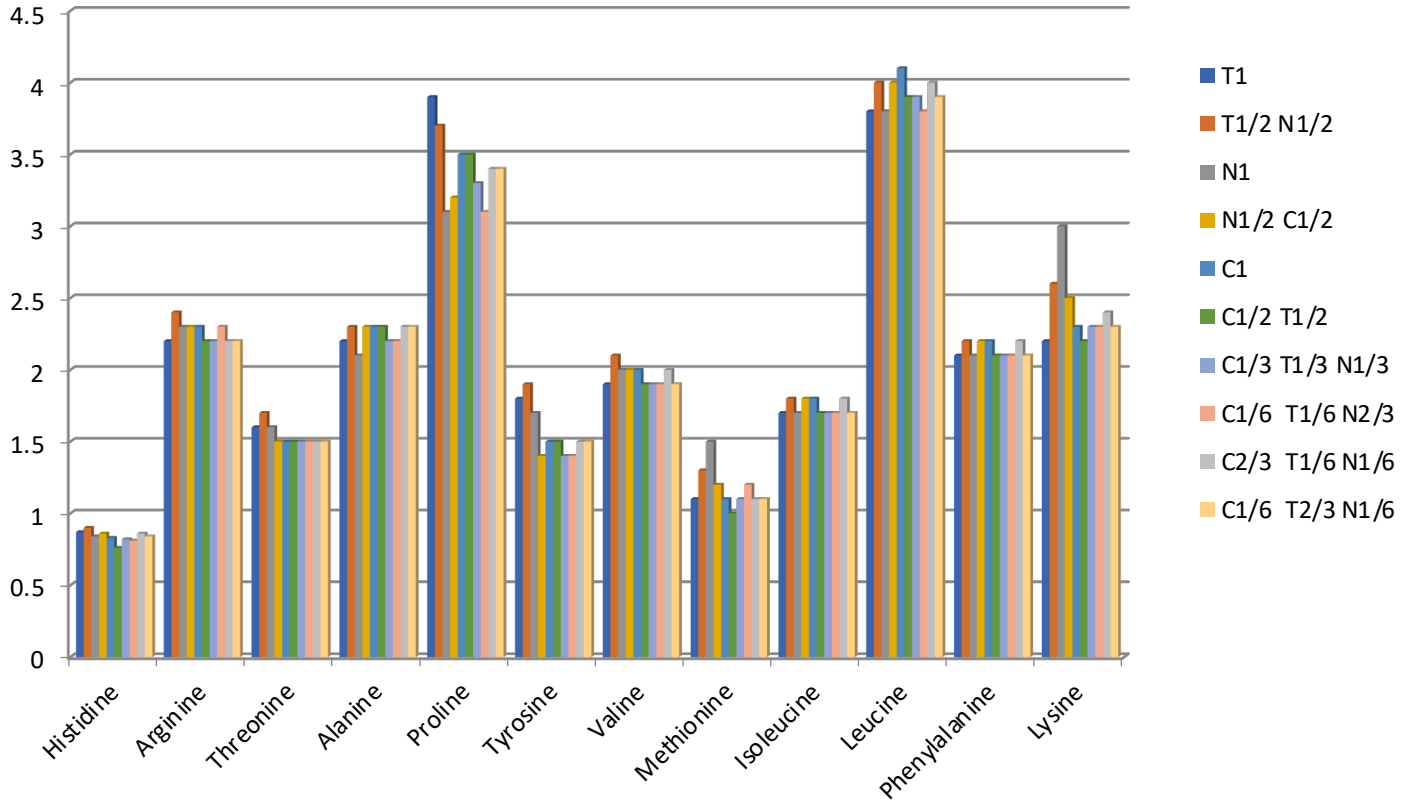
Vork Dambrug

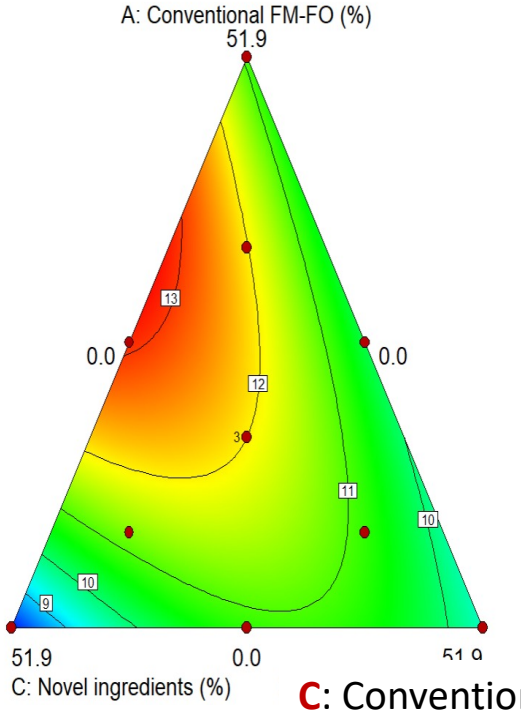
Binderup Mølle Farm

Atlantic salmon

SALMAR Passion for Salmon

GIFAS





C: Conventional FM-FO

T: Trimmings FM-FO

N: Novel ingredients

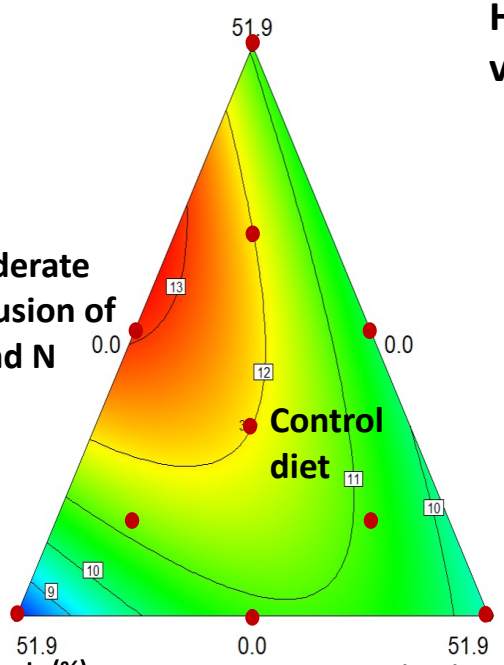
Novel ingredients

- *Bacterial protein*
- *Yeast meal*
- *Microalgae*

Lower values

Higher values

Conventional FM-FO (%)



Moderate inclusion of C and N

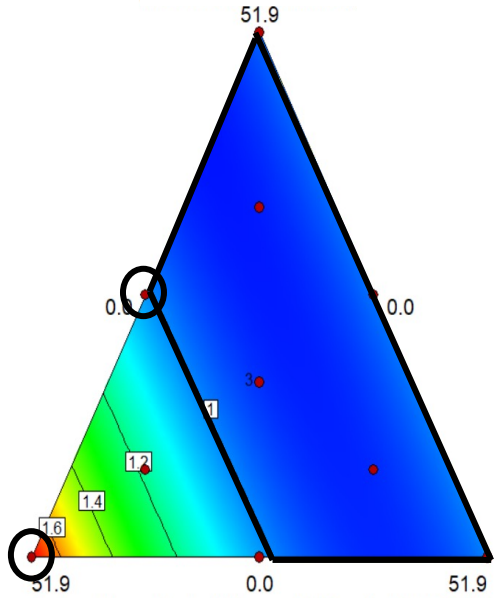
Control diet

Novel ingredients (%)

Trimmings FM-FO (%)

Total period

Conventional FM-FO (%)

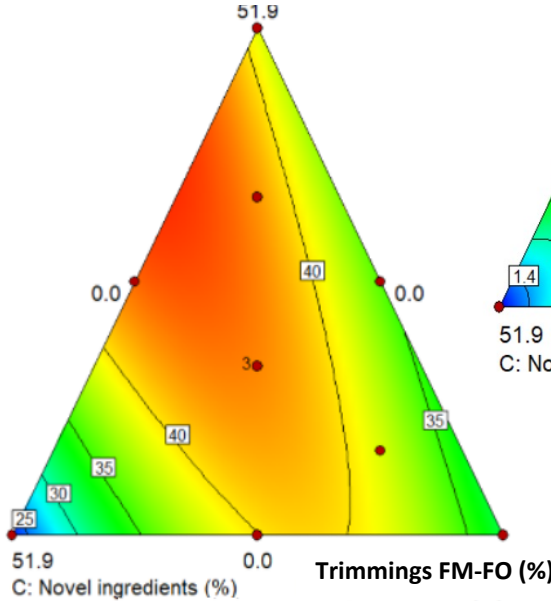


Novel ingredients (%)

Trimmings FM-FO (%)

FCR_end

Conventional FM-FO (%)

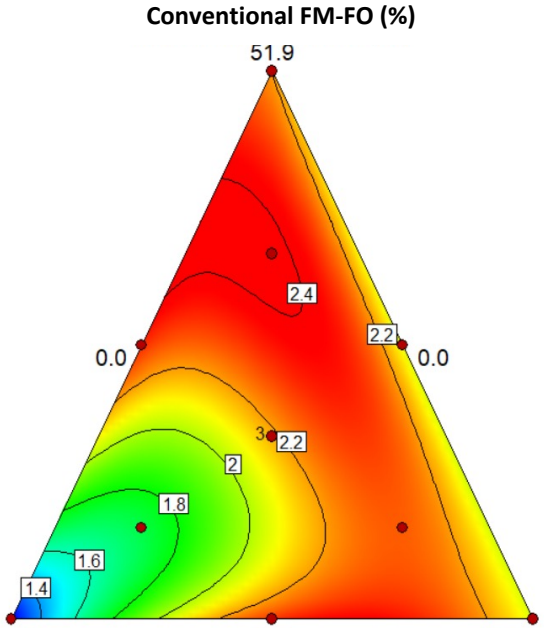


C: Novel ingredients (%)

Trimmings FM-FO (%)

Feed intake (g/fish)

Conventional FM-FO (%)

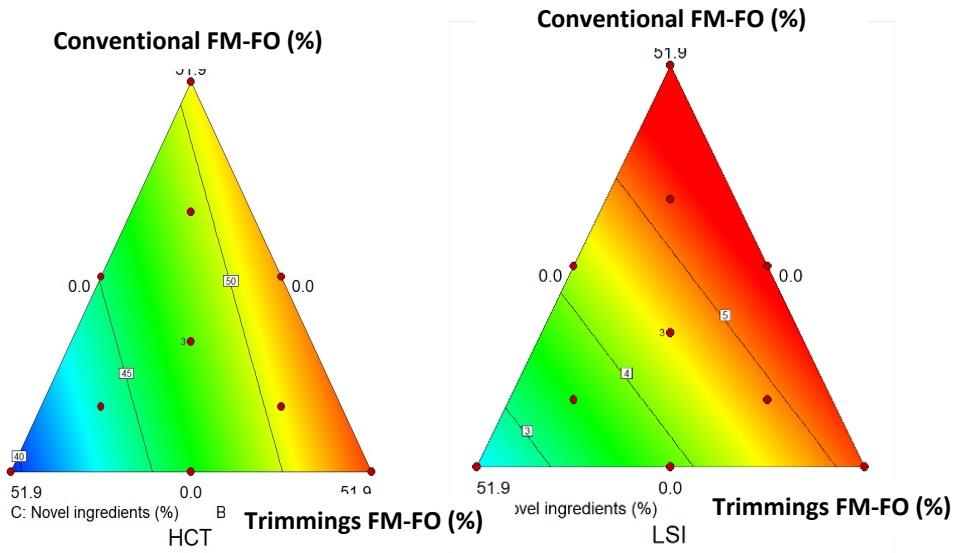


C: Novel ingredients (%)

Trimmings FM-FO (%)

SGR_end

Conclusions



Haematocrit (HCT)

Liposomatic (LSI)

Best growth and FCR for **Conventional** and **Trimmings** mixture with **moderate** inclusion **of Novel ingredients**

Negative effects of exclusive inclusion of **Novel** ingredients possibly due to:

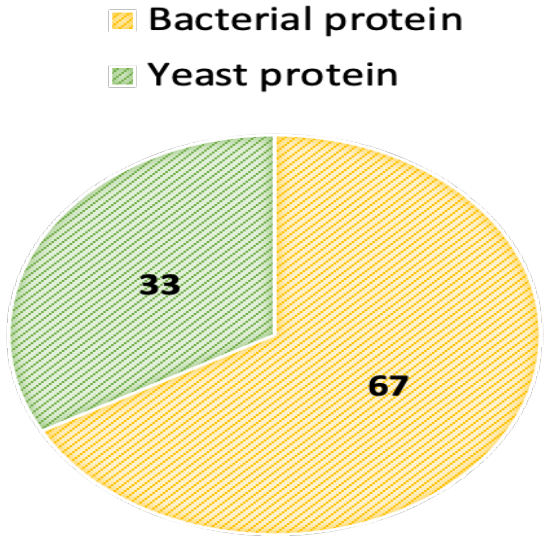
- Lower palatability (try palatability enhancers next)
- Lower digestibility

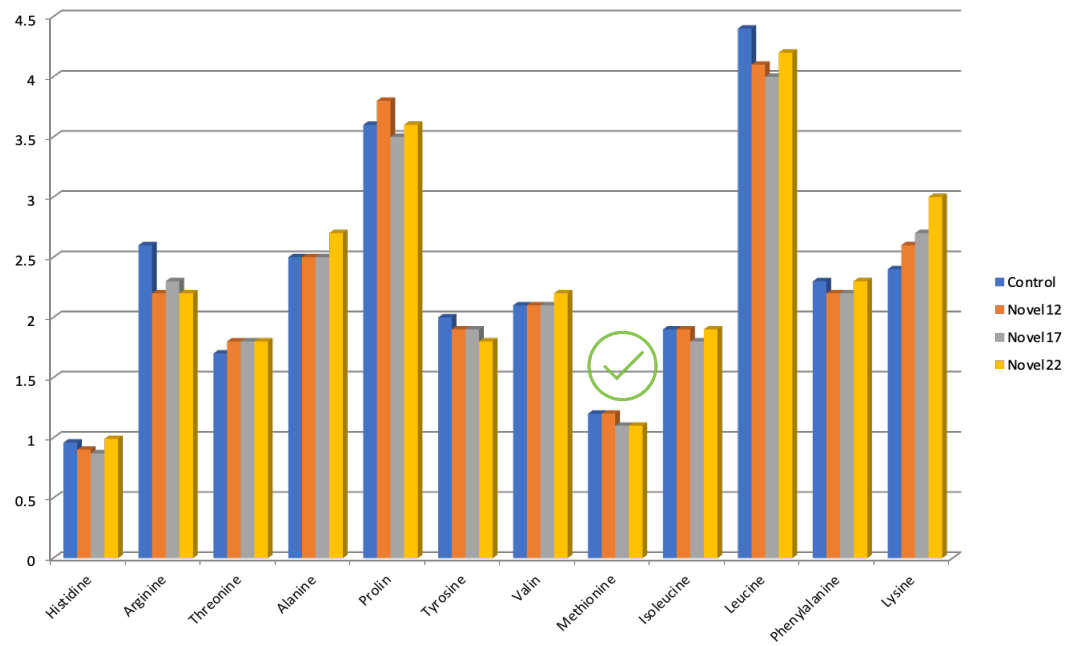
Ensure optimum mineral composition when use novel non marine source ingredients (Low haematocrit)

More fat was accumulated in both intestinal and liver tissues of **Conventional** and **Trimmings** fed groups. Possibly related to increased feed intake and final weight

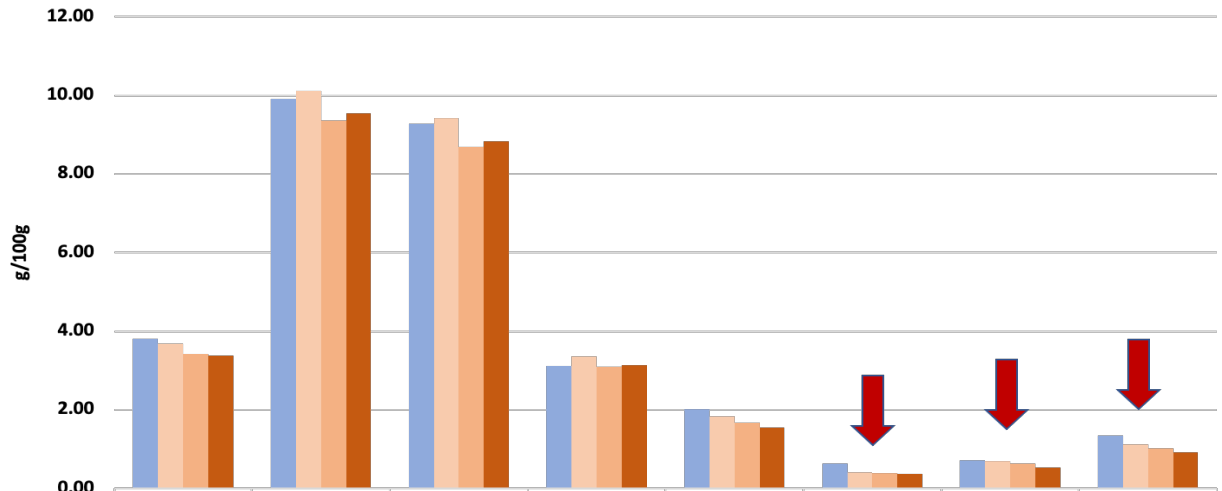
The histopathological examination of the liver showed minimal (steatosis) lipid accumulation for Trimming mixture with moderate inclusion of Novel ingredients

Novel ingredients mixture

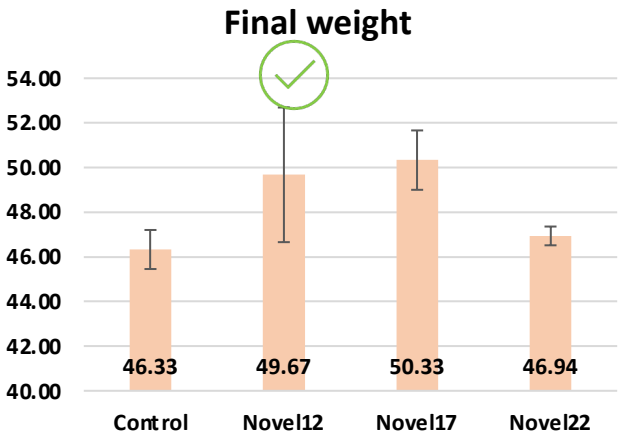


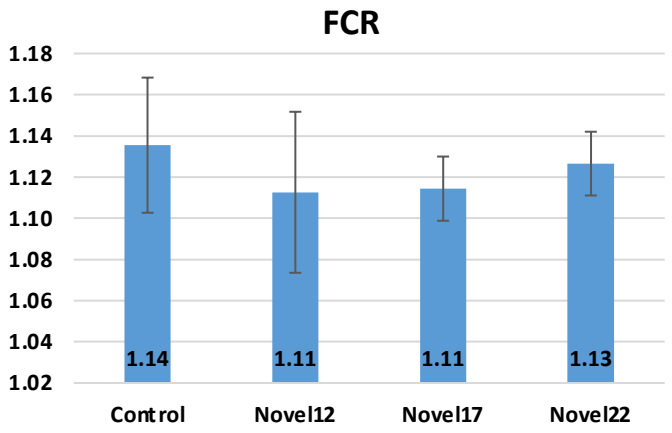


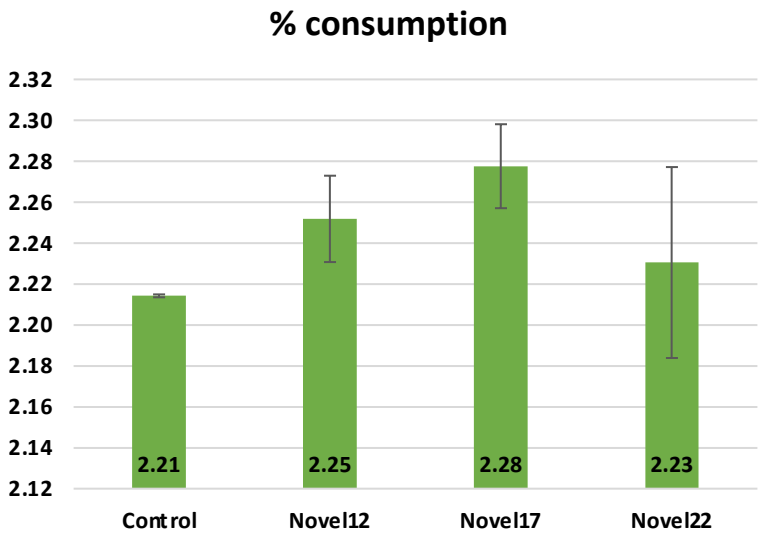
Fatty acids

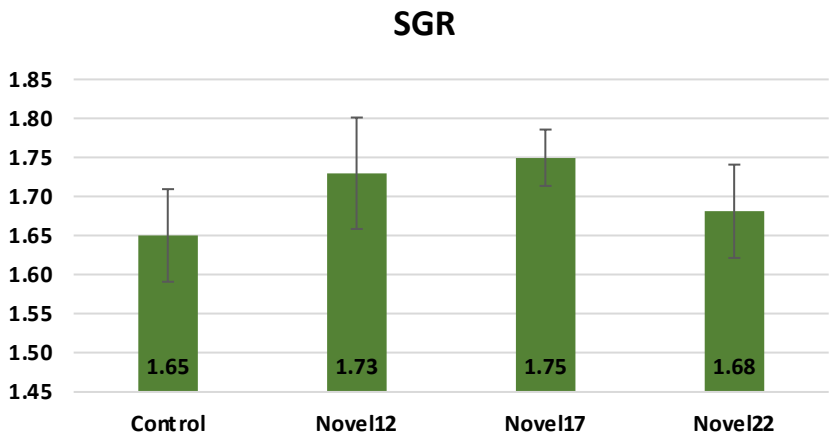


	Saturated	Monounsaturated	∑n-9	∑n-6	∑n-3	EPA	DHA	EPA+DHA
Control	3.81	9.90	9.29	3.11	2.02	0.63	0.73	1.35
Novel12	3.68	10.11	9.43	3.35	1.83	0.42	0.70	1.12
Novel17	3.42	9.37	8.68	3.10	1.67	0.39	0.63	1.02
Novel22	3.39	9.55	8.83	3.14	1.55	0.38	0.54	0.92

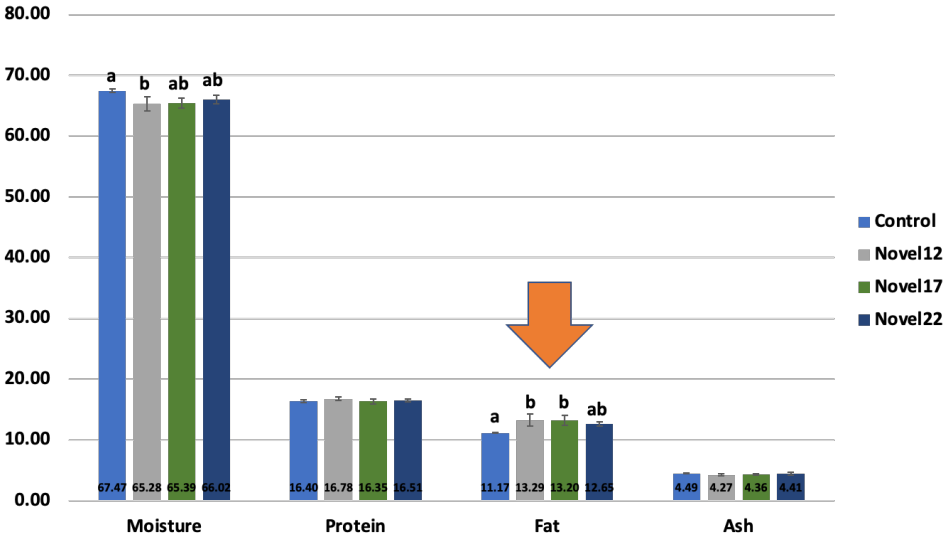


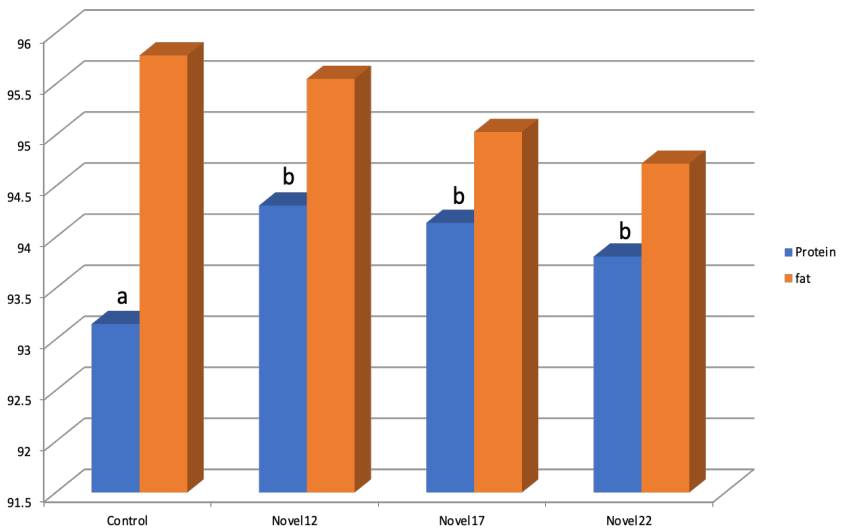


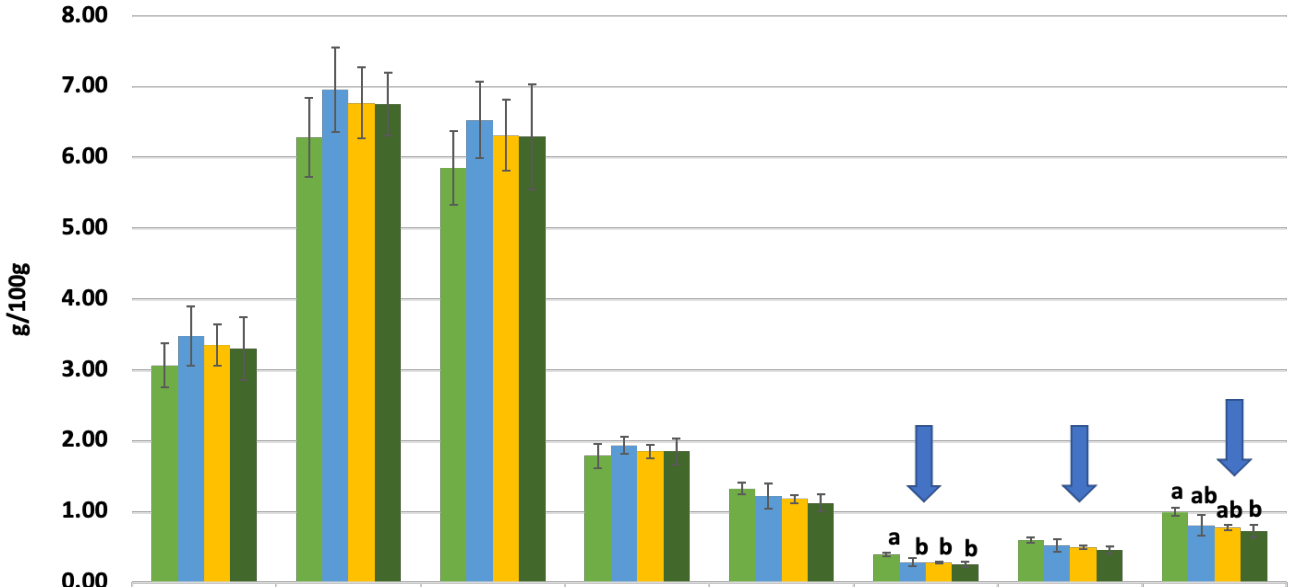




- ✓ Trent observed for higher final weight of moderate inclusion of Novel ingredients
- ✓ Improved FCR at moderate inclusion of Novel ingredients



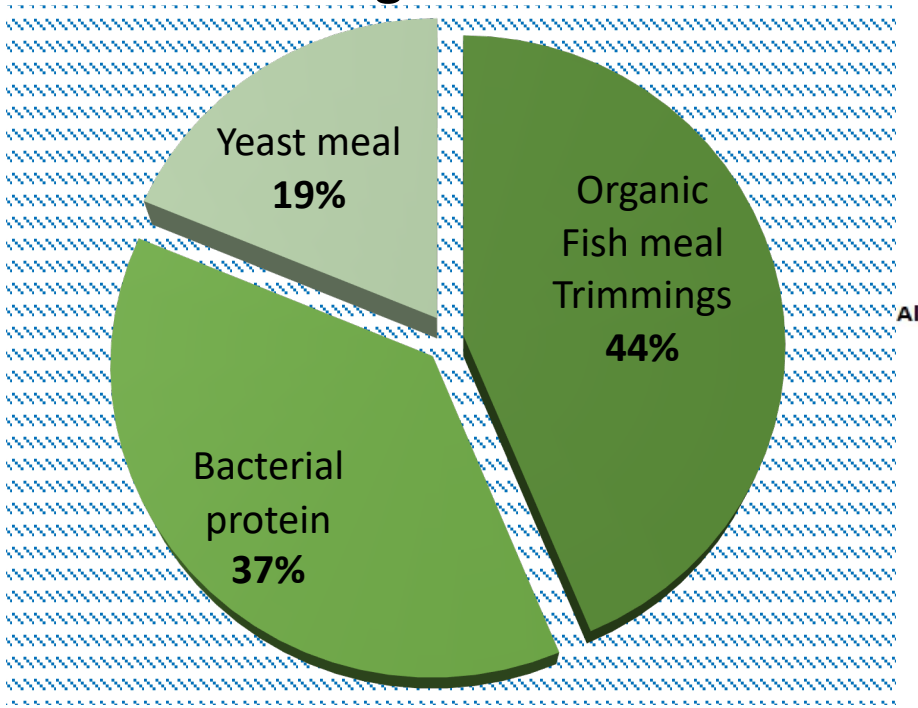


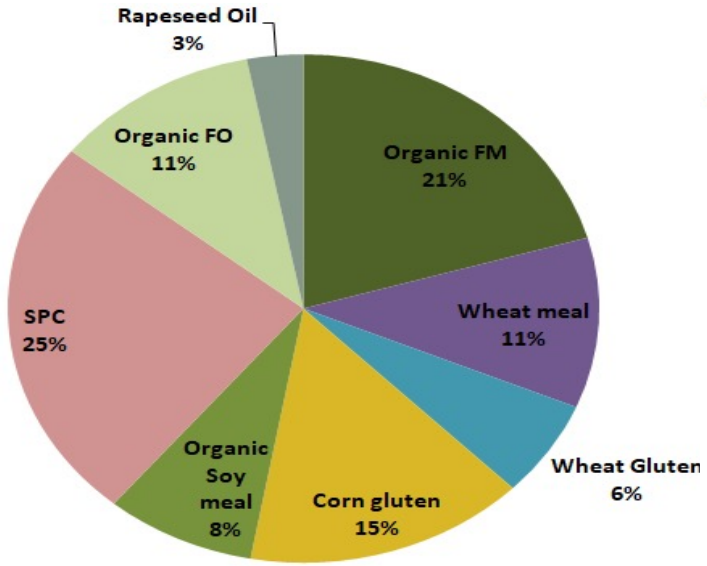


	Saturated	Monounsaturated	∑n-9	∑n-6	∑n-3	EPA	DHA	EPA+DHA
Control	3.07	6.29	5.85	1.79	1.33	0.40	0.60	1.00
Novel12	3.48	6.96	6.53	1.94	1.22	0.29	0.52	0.81
Novel17	3.35	6.77	6.32	1.85	1.18	0.28	0.50	0.78
Novel22	3.31	6.75	6.29	1.85	1.12	0.26	0.46	0.72

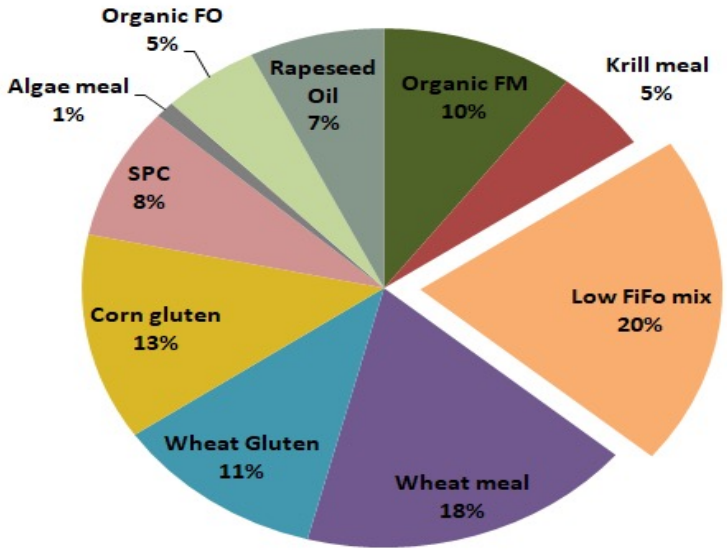
Diet 1 0% Low FiFo
Diet 2 20% Low FiFo
Diet 3 25% Low FiFo
Diet 4 30% Low FiFo

Low FiFo for organic diets

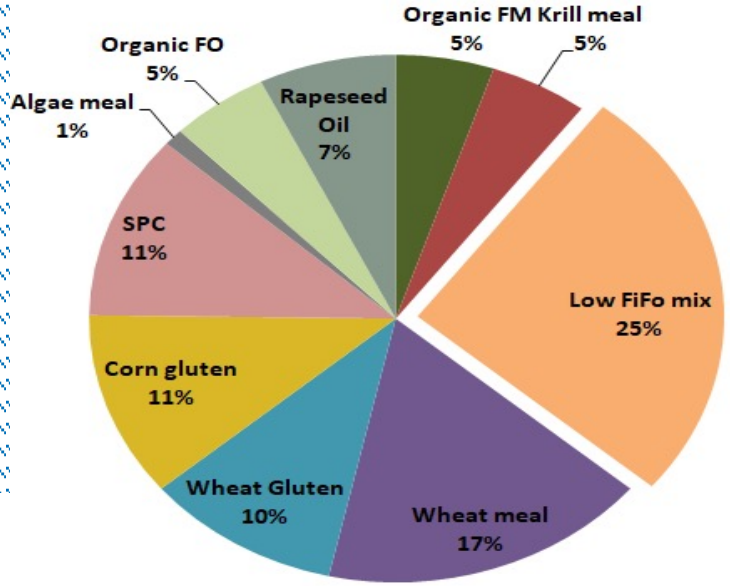




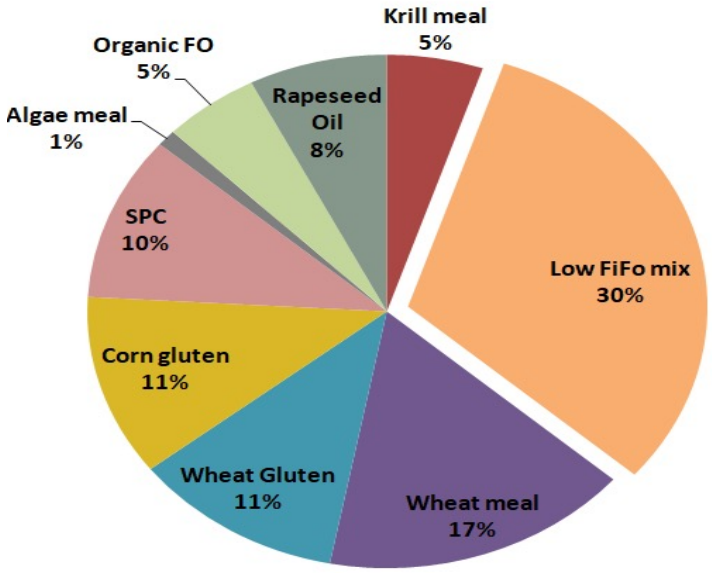
Diet 1



Diet 2



Diet 3



Diet 4

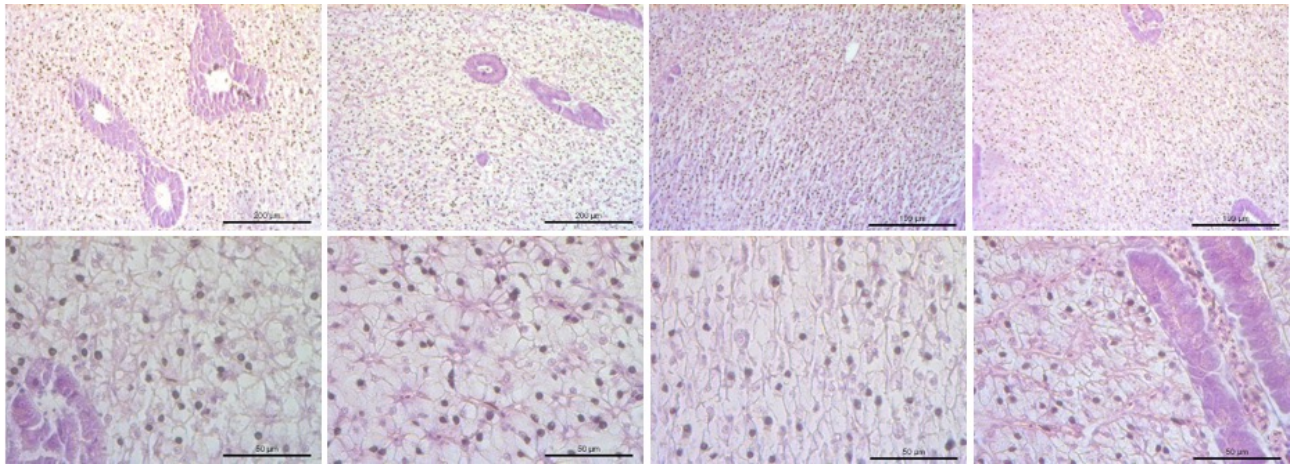
Growth evaluation

	Control	LFiFo20	LFiFo25	LFiFo30
Final weight (g)	14.65±0.46^{a}	19.44±0.48^{b}	19.86±0.49^{b}	19.37±0.45^{b}
Weight gain (g)	7.58±0.11^{a}	12.37±0.57^{b}	12.75±0.35^{b}	12.14±0.97^{b}
SGR (%/day)	1.21±0.02^{a}	1.68±0.07^{b}	1.69±0.04^{b}	1.63±0.08^{b}
FCR	1.28±0.07^{a}	1.05±0.02^{b}	0.99±0.03^{b}	0.99±0.04^{b}
Voluntary Feed intake (% BW/day)	1.49±0.10^{a}	1.63±0.09^{a}	1.56±0.09^{a}	1.51±0.11^{a}

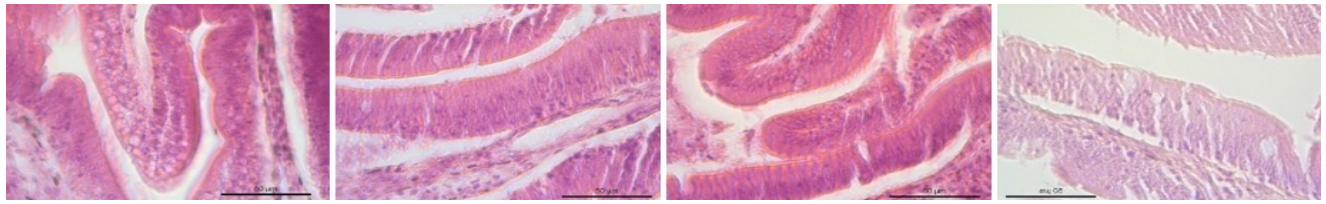
Higher growth performance for LFiFo25 diet compared to control diet

Health evaluation

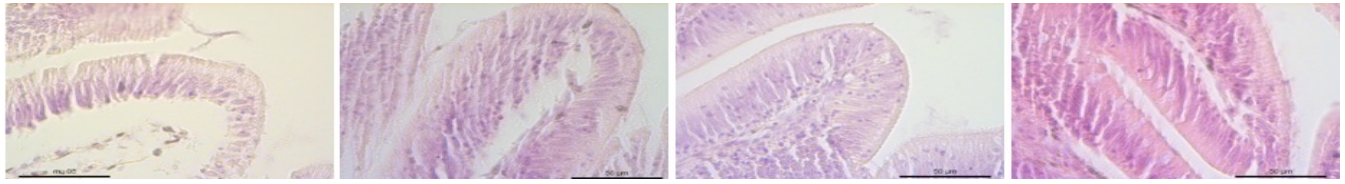
Control Diet LFiFo20 LFiFo25 LFiFo30



Liver in control diet appears to have normal structure, but in replacement diets there is a slight nuclei displacement due to lipid droplets.



Anterior gut appears to have normal structure in all dietary groups with normal distribution of goblet cells.

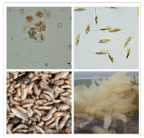


Posterior gut appears to have normal structure in all dietary groups with normally distribution of goblet cells. There are no signs of inflammation.

FUTURE EUAQUA

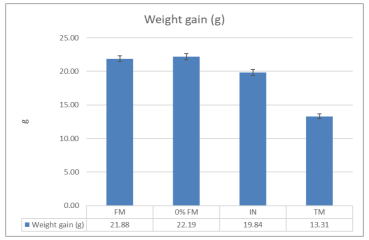
Diet 1 Control (FM)

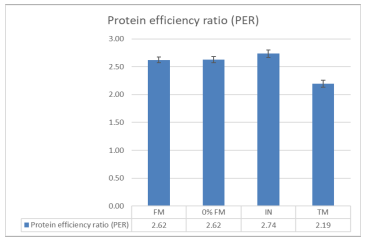
Diet 2 total replacement of fishmeal (0% FM)

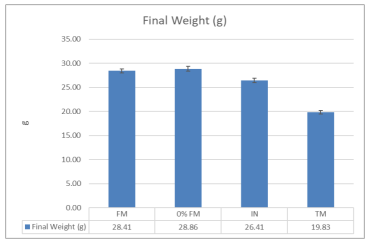


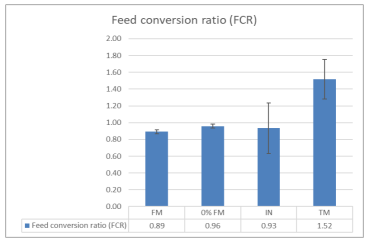
Diet 3 68.09% replacement of fishmeal (IM)

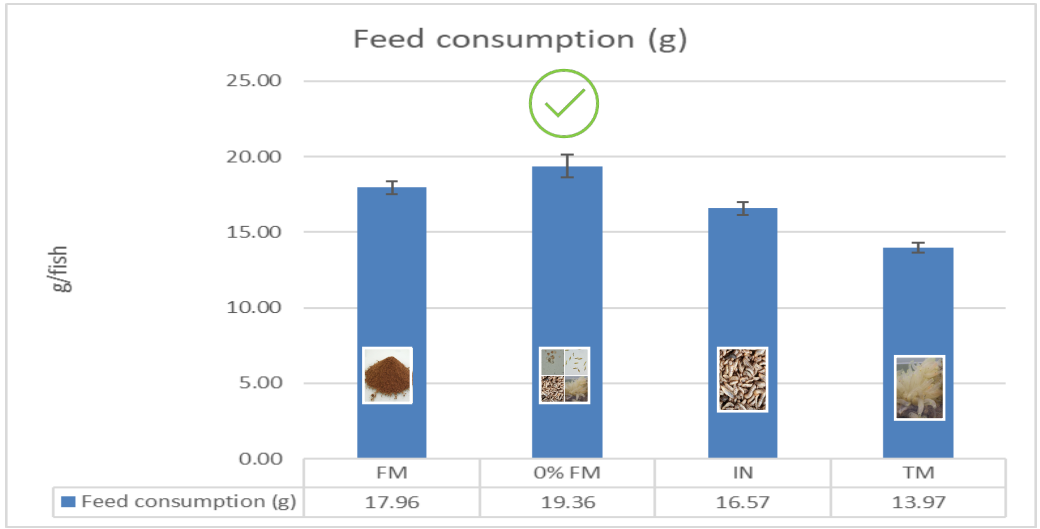
Diet 4 45.91% replacement of fishmeal (TM)

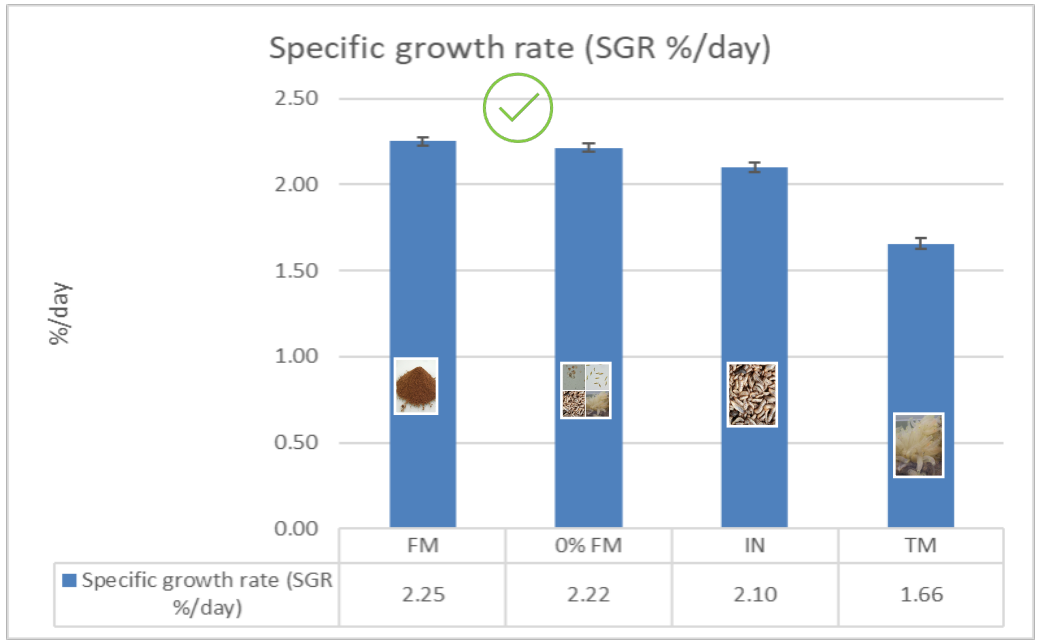












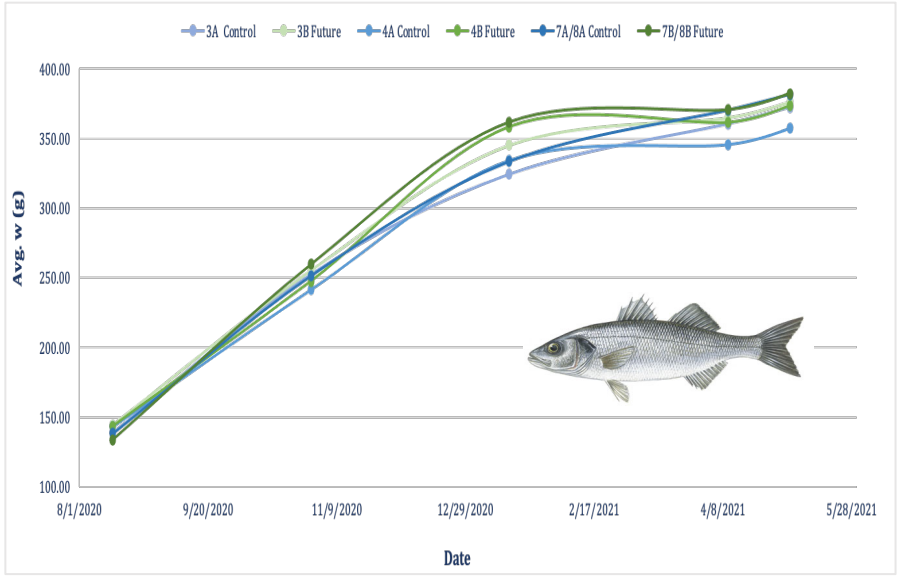
FUTURE EU AQUA

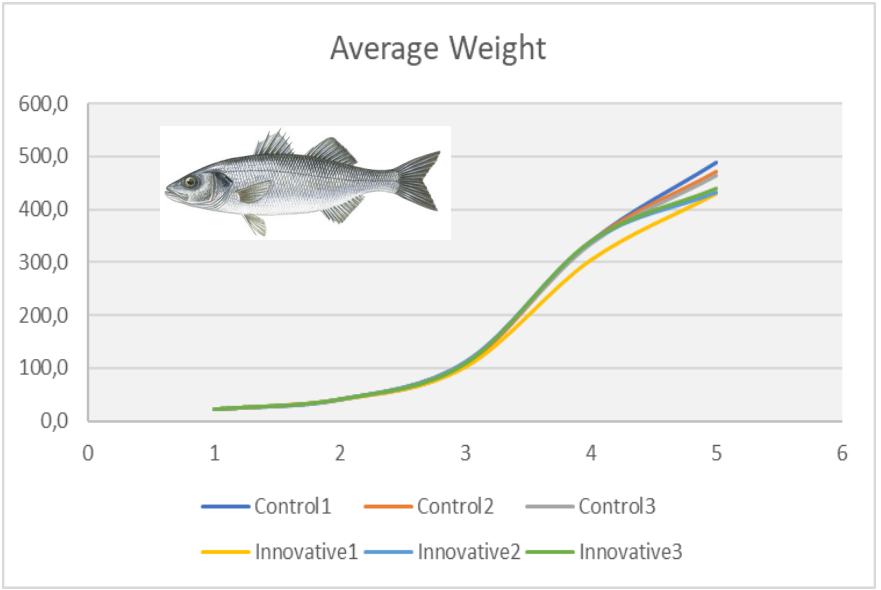
	FM	0% FM	IM	TM	PA	HA
FCR	0.89 ± 0.03^{a}	0.98 ± 0.03^{a}	0.93 ± 0.04^{a}	1.5 ± 0.18^{b}	0.81 ± 0.01^{a}	0.93 ± 0.01^{a}
SGR (%BW/day)	2.54 ± 0.03^{b}	2.4 ± 0.03^{b}	2.4 ± 0.04^{b}	1.84 ± 0.04^{a}	3.1 ± 0.02^{c}	3.13 ± 0.02^{c}
PER	$2.7\pm0.05^{b,c,d}$	$2.67\pm0.06^{b,c}$	$2.82\pm0.07^{c,d}$	2.24 ± 0.06^{a}	2.92 ± 0.04^{d}	2.52 ± 0.04^{b}
Survival (%)	91.71 ± 2.88^{a}	$97.82\pm0.58^{a,b}$	$95.86\pm1.44^{a,b}$	$96.13\pm1.09^{a,b}$	98.88 ± 0.55^{b}	99.44 ± 0.55^{b}

The total replacement of fishmeal with algae meal, (*Phaeodactylum tricornutum* and *Schizochytrium limacinum),*insect meal (black soldier fry) and tunicate meal (*Chiona intestinalis*) and no fish oil did not affect sea bream growth performance.

However, sea breams showed better growth performance when they fed organic fish meal, krill, and algae (*Schizochytrium limacinum*, HA) and *Phaeodactylum tricornutum*, PA) and slow growth rates when they fed on tunicate meal.

Mediterranean species (sea bream and sea bass)





Select
raw materials

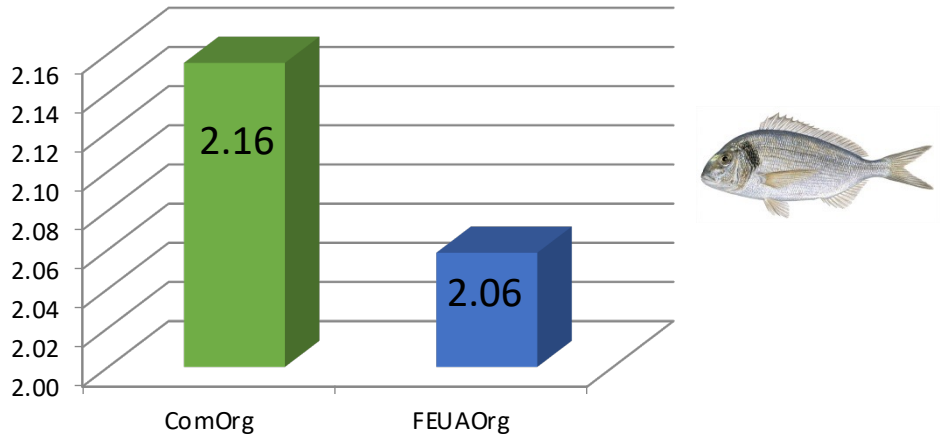
FM and FO, krill meal, squid meal

Mineral and Vitamin premix

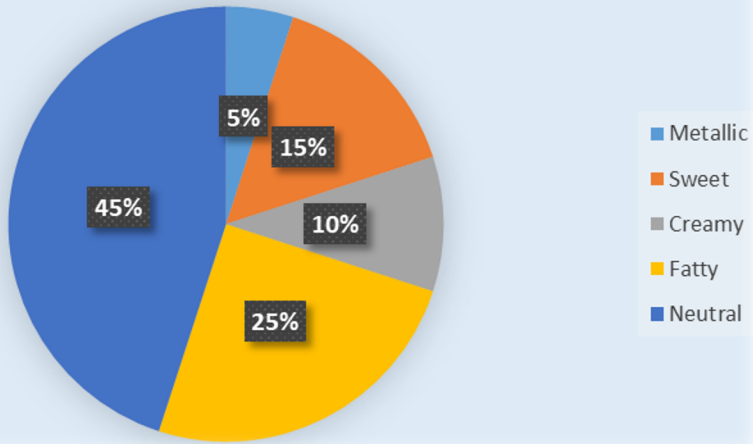
Novel ingredients

- *Pea protein*
- *Yeast*
- *Fermented soya*

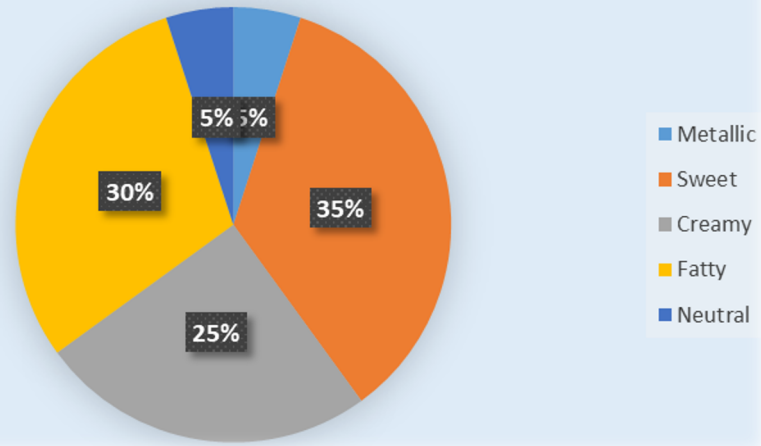
FCR - Organic



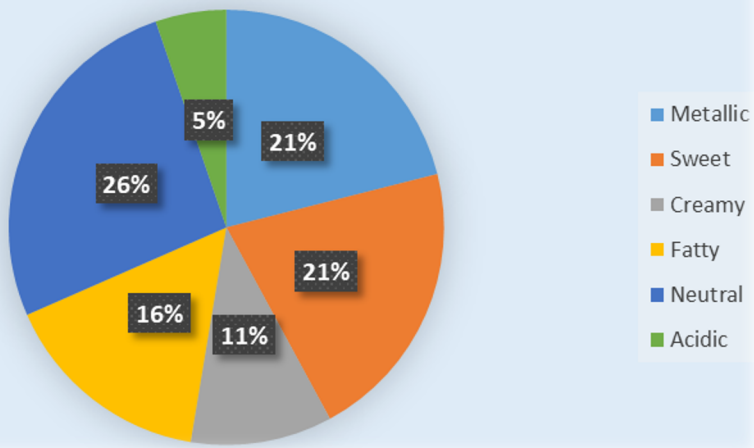
Commercial fish fillet taste



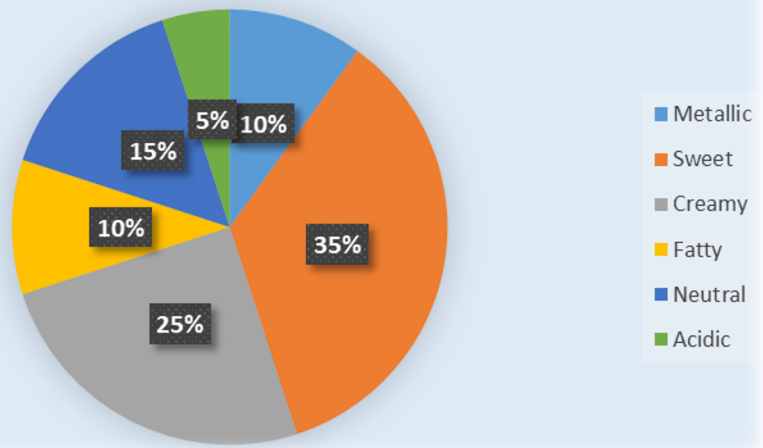
Future fish fillet taste



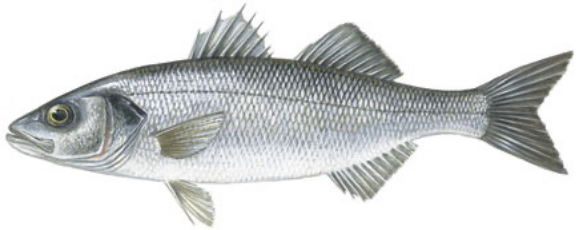
Commercial fish fillet aftertaste

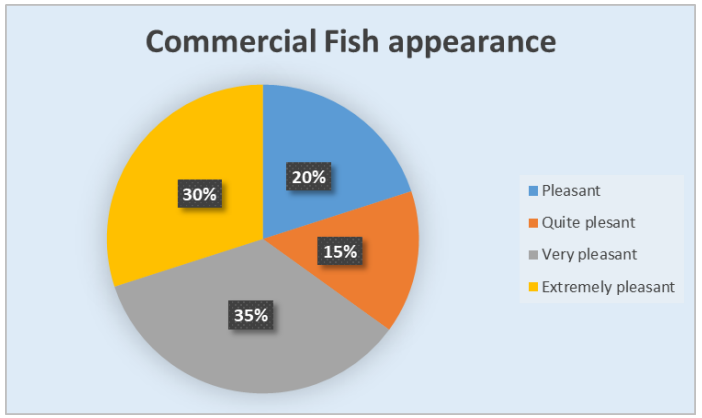


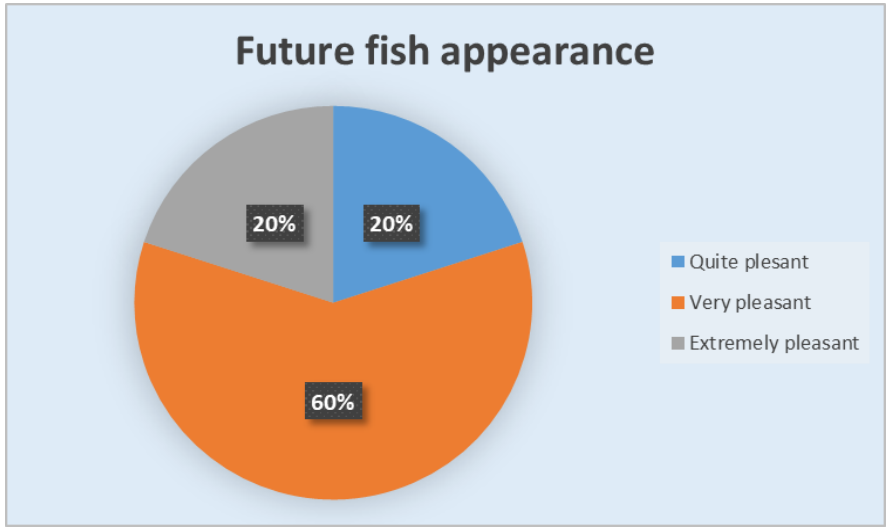
Future fish fillet aftertaste

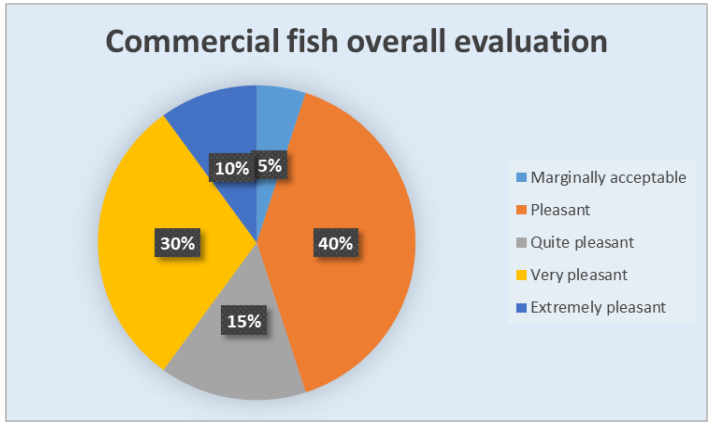


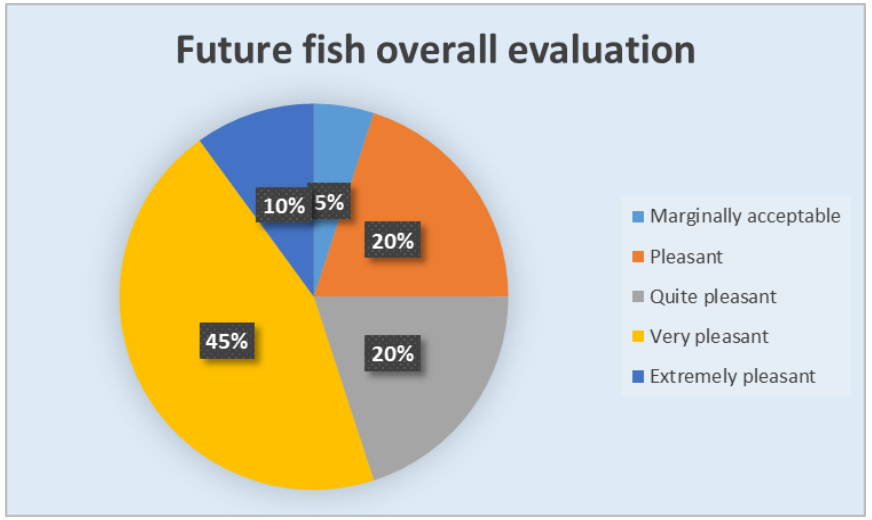
Sea bass appearance and overall evaluation











Ingredients to be tested for conventional trout farming

Fermented rapeseed meal and fermented soybean meal

Why ?

Soy bean are no. 1 protein source in aquaculture feeds and exists in various qualities and may contain antinutritional factors

- Fermentation may deactivate antinutritional factors and reduce undesirable substances

Ingredients to be tested for organic trout farming

- Rules for antinutrient removal has to follow organic rules. Organic regulation does not allow synthetic amino acids to balance diets – hence one of few high protein alternatives is fish meal.

Fish meal protein concentrate processed from trimmings

Why ?

Traditional fish meal or fish trimmings has an environmental draw back with a high phosphorus (P) content. New technology has developed this type with low P content and high protein content **(>80 % protein)** -thus allowing high protein and high energy – not common in organic diets.

Trout conventional trials

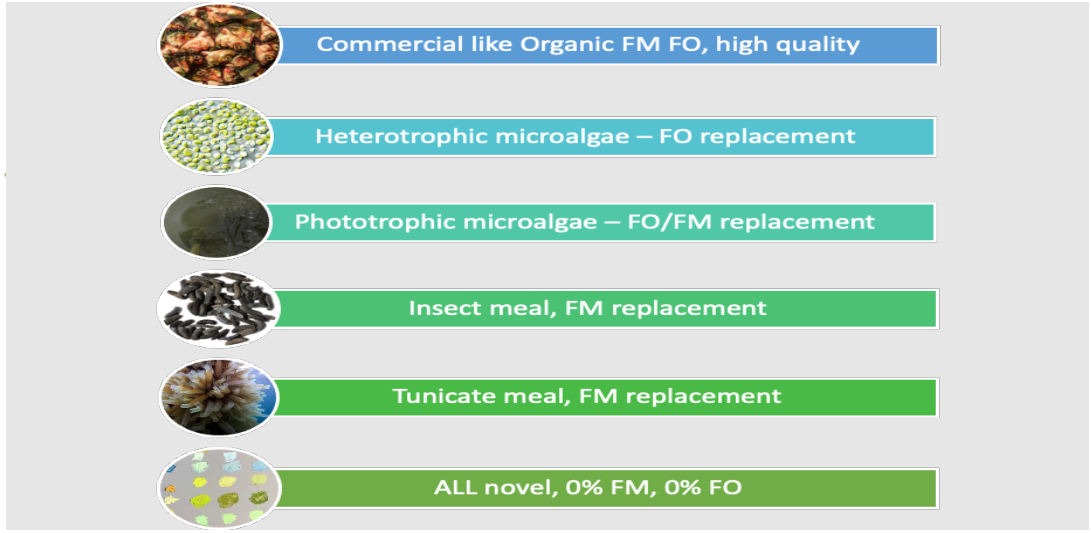
Diet	SBM	RSM	SBMF	RSMF
SGR total	**1.34±0.01$_a$**	1.15±0.05$_b$	1.29±0.04$_a$	1.17±0.02$_b$
FCR*total	**1.24±0.02$_a$**	1.49±0.06$_b$	1.28±0.04$_a$	1.46±0.03$_b$

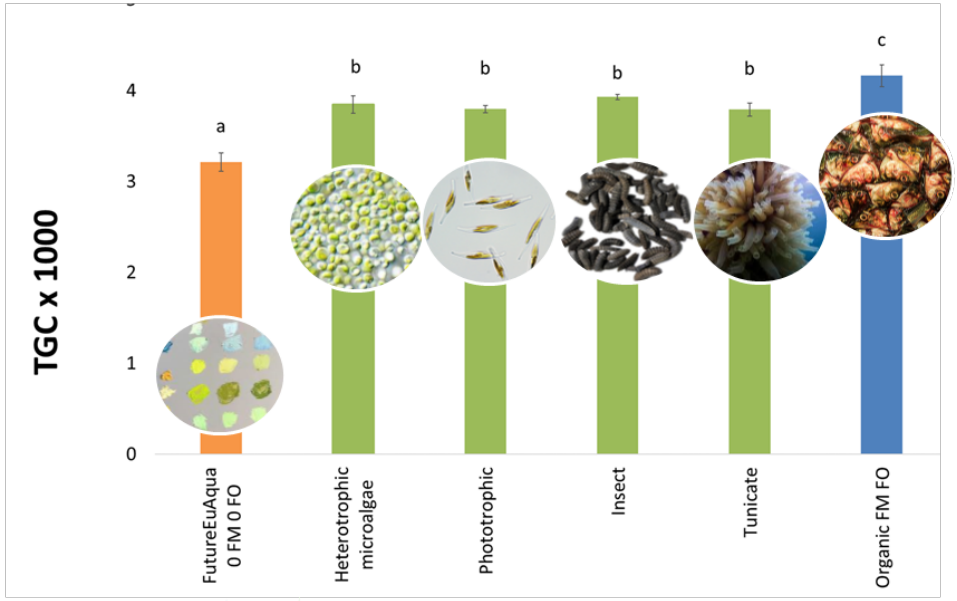
For entire experiment there was a significantly better SGR and a lower FCR for soybean (SBM) and fermented soybean meal (SBMF) as compared with diet rapessed meal (RSM) and fermented rapeseed meal **(**RSMF). There were no statistically difference between SBM and SBMF or RSM and RSMF.

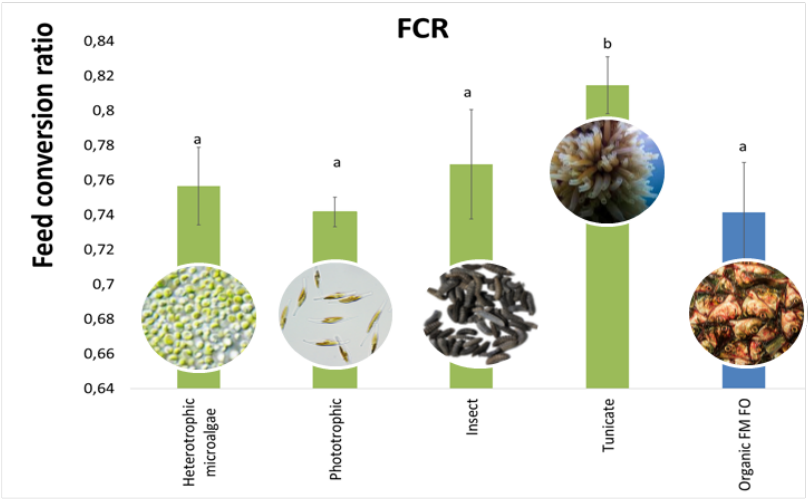
Trout organic trials

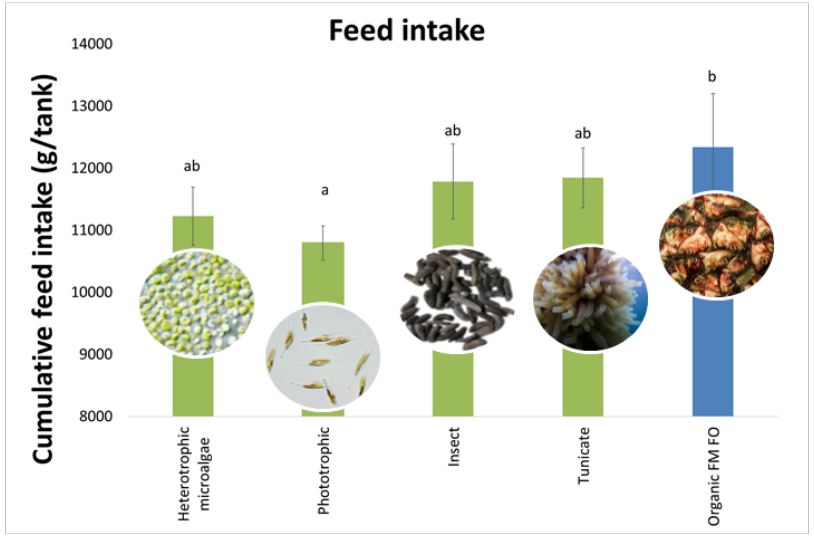
Diet	CTR	CTR2	T1	T2
SGR	1.98±0.07	2.02±0.05	1.98±0.13	2.04±0.08
FCR*	0.79±0.04	0.72±0.06	0.70±0.02	0.75±0.05

There were no significantly differences in SGR, FCR between diets.

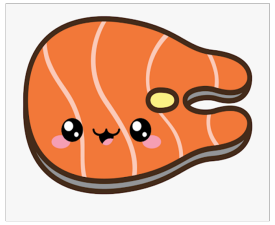

Commercial like Organic FM FO, high quality
Heterotrophic microalgae – FO replacement
Phototrophic microalgae – FO/FM replacement
Insect meal, FM replacement
Tunicate meal, FM replacement
ALL novel, 0% FM, 0% FO

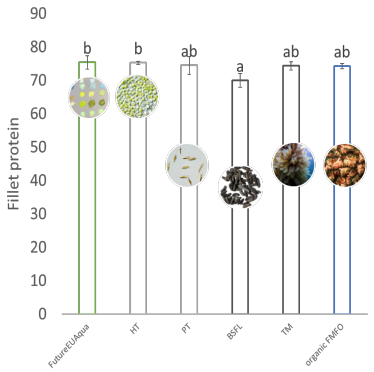

TGC x 1000
0
1
2
3
4
a
b
b
b
b
c
FutureEuAqua 0 FM 0 FO
Heterotrophic microalgae
Phototrophic
Insect
Tunicate
Organic FM FO

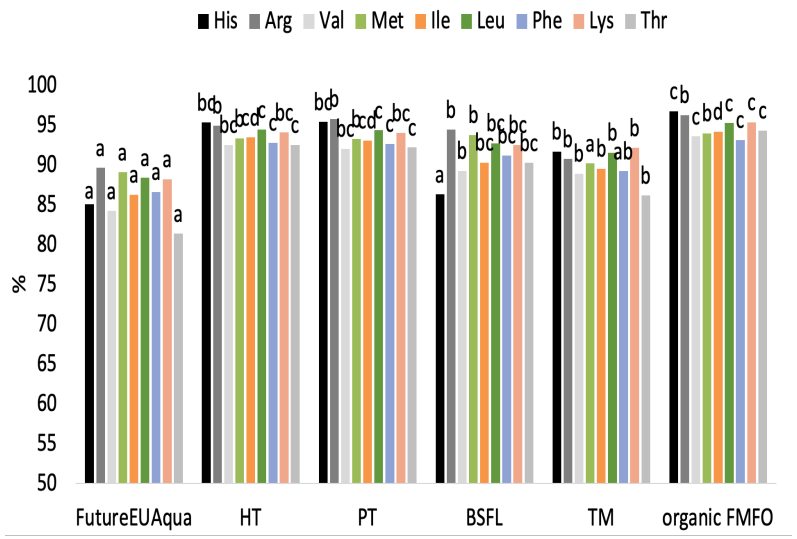

FCR
Feed conversion ratio
0,64
0,66
0,68
0,7
0,72
0,74
0,76
0,78
0,8
0,82
0,84
a
a
a
b
a
Heterotrophic microalgae
Phototrophic
Insect
Tunicate
Organic FM FO


Feed intake
Cumulative feed intake (g/tank)
8000
9000
10000
11000
12000
13000
14000
ab
a
ab
ab
b
Heterotrophic microalgae
Phototrophic
Insect
Tunicate
Organic FM FO

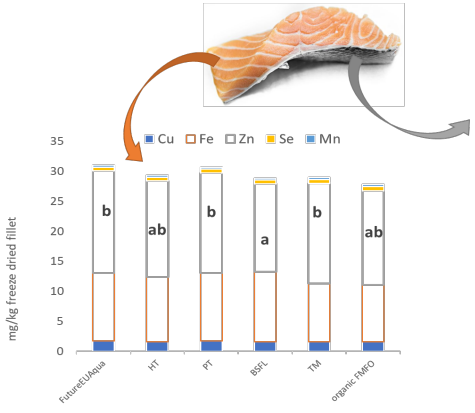
7. PRODUCT QUALITY, FILLET PROTEIN

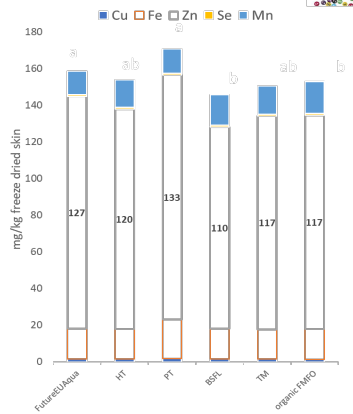




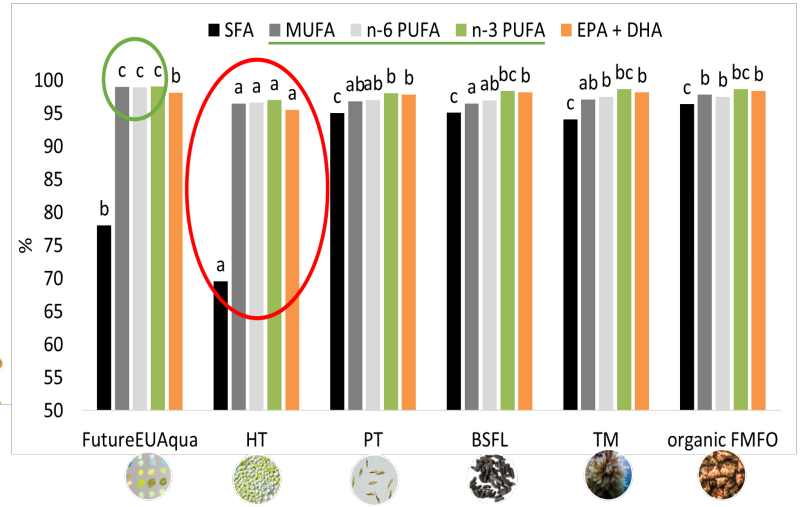


7. HEALTH (SKIN AND FILLET MINERALISATION) AND QUALITY

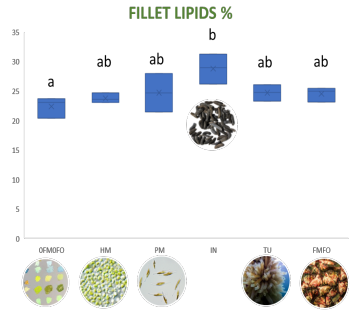


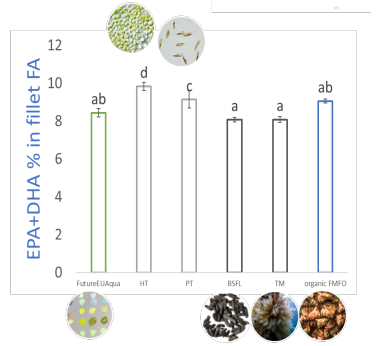


INCREASED **FILLET** AND **SKIN ZN** LEVELS IN THE **PT MICROALGAE** GROUPS



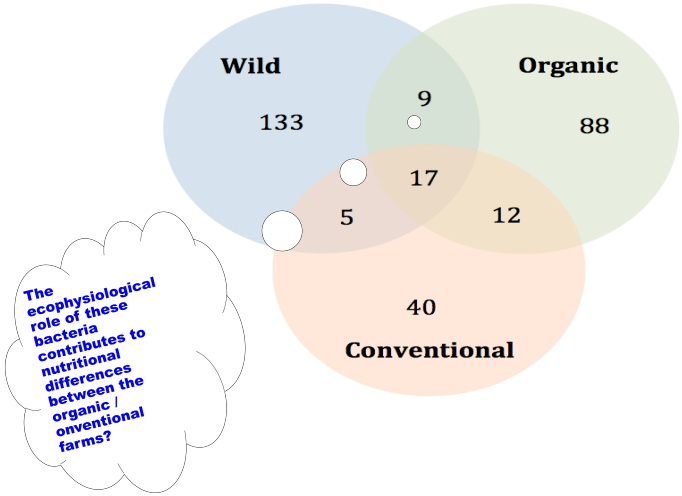
7. LIPID/ENERGY METABOLISM AND PRODUCT QUALITY





Fish gut microbiota and nutrition

Gut microbial diversity could be influenced
by nutrition or environmental factors
but few studies on fish and crustaceans are available that experimentally confirm this.



AIMS FutureEUAqua

- Do gut bacterial communities exhibit temporal shifts/diversity mostly relating to temporal variations in food supply of nutrients?

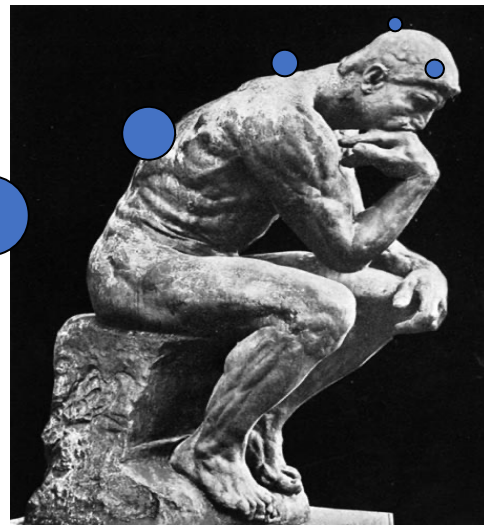
- Which are the gut bacterial communities that could serve as providers of essential nutrients to fish?

Diet is a major factor driving the composition and metabolism of the gut microbiota while gut microbiota is actively involved in nutrient assimilation and immunity of the host organism.

FISH FEEDS
Novel
ingredients
technology

ECOLOGICAL
environmentally
sound
Aquaculture

FutureEUAqua



Understanding
the ways of
utilisation of
sustainable
innovative
tailor-made
diets in farmed
fish

NUTRITION
Nutritional
physiology
research

FUTURE EUAQUA

European research and innovation that, while achieving the research needed, provides the base necessary for knowledge management for aquaculture in the future.

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Thank you!!!