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Weaning of grey mullet fry with diets differing in fish meal levels

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Generalitat de Catalunya

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The trial was carried out in an IRTA Mar recirculation system with 12 100L tanks, using an experimental design of 4 different feeding conditions with 3 replicates (200 fish/tank). Fish (202±5 mg initial weight) were obtained from a local dealer and transported by road to IRTA where they were acclimated and treated to avoid any pathogen or parasite.

Rearing conditions were 18±0.5ºC, 1.2±0.2 ppt salinity, 6.5±0.5 mg/L oxygen, 10hL:14hD photoperiod.

Feeding protocol

i) days 0-5: 100% live 6 days-old Artemia metanauplii (15-20 metanauplii/mL);

ii) days 6-10: 75% Artemia metanauplii + 25% inert feed (FM, PP50, PP75);

iii) days 11-15: 50% Artemia metanauplii + 50% inert feed (FM, PP50, PP75);

iv) days 16-20: 25% Artemia metanauplii + 75% inert feed (FM, PP50, PP75);

v) days 21-60: 100% inert feed (FM, PP50, PP75).

Ingredients	FM	PP50	PP75
	%	%	%
Fishmeal 70 LT	32,000	16,000	8,000
Hydrolized fish protein concentrate	5,000	5,000	5,000
Soy protein concentrate	0,000	5,000	7,000
Wheat Gluten	0,000	6,900	10,500
Corn gluten	0,000	5,000	7,000
Soybean meal 48	6,000	6,000	6,000
Rapeseed meal	5,300	5,300	5,300
Sunflower meal	5,300	5,300	5,300
Wheat meal	16,500	12,600	11,000
Pea starch	12,500	12,500	12,500
Fish oil	11,300	12,500	13,100
Vit & Min Premix PV01	1,500	1,500	1,500
Soy lecithin	1,000	1,000	1,000
Binder	1,500	1,500	1,500
Antioxidant	0,200	0,200	0,200
Dicalcium phosphate	1,700	3,000	4,000
L-Lysine	0,000	0,400	0,700
DL-Methionine	0,200	0,300	0,400
Total	100,000	100,000	100,000

As fed basis	FM	PP50	PP75
Crude protein	36,0	35,9	35,9
Crude fat	15,8	15,9	15,9
Fiber	2,5	2,7	2,8
Starch	14,8	14,2	13,8
Gross Energy	19,3	19,4	19,3
Lys	2,4	2,3	2,4
Met + Cys	1,6	1,6	1,6
Total P	1,1	1,1	1,2
Ca	1,5	1,5	1,5

The experimental diets (0.8 mm pellet) were formulated and manufactured by Sparos Lda (Portugal). Fish meal was partially substituted at 50 and 75% with plant proteins (corn gluten, wheat gluten and soy protein concéntrate). All the diets were isoproteic (36%), isolipid (16%) and isoenergetic.

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	Control	PP50	PP75
Total lipids (mg DW)	158.0 ± 2.0	159.0 ± 2.0	159.0 ± 2.0
Total Fatty acids (mg/g lipids)	688.5 ± 68.6	758.2 ± 16.4	731.0 ± 4.6
Fatty Acids (mg/g lipids)			
16:0	119.4 ± 2.4	115.6 ± 2.3	114.2 ± 3.0
Total Saturated (SFA)	**172.6 ± 6.5 a**	**159.6 ± 4.9 b**	**151.2 ± 5.9 b**
18:1n-9	79.7 ± 1.3	82.3 ± 1.9	79.4 ± 1.2
Total Monounsaturated (MUFA)	**318.0 ± 2.2**	**324.9 ± 4.2**	**312.9 ± 2.2**
18:2n-6	*42.9 ± 1.1 b*	*58.1 ± 0.5 a*	*61.4 ± 1.3 a*
20:4n-6 (ARA)	2.7 ± 0.3	3.0 ± 0.1	2.8 ± 0.3
Total n-6	***46.3 ± 1.0 b***	***61.7 ± 0.3 a***	***66.3 ± 1.2 a***
18:3n-3	10.7 ± 0.5	12.3 ± 0.2	11.6 ± 0.5
18:4n-3	*26.8 ± 0.3 b*	*28.2 ± 0.2 a*	*28.1 ± 0.1 a*
20:5n-3 (EPA)	75.2 ± 1.2	79.8 ± 0.8	77.3 ± 1.9
22:6n-3 (DHA)	75.5 ± 1.1	78.1 ± 1.6	73.0 ± 1.9
Total n-3	**200.1 ± 3.4**	**211.9 ± 2.7**	**202.9 ± 4.7**
Tota PUFA	***246.4 ± 4.1 b***	***276.7 ± 2.4 a***	***269.2 ± 6.2 a***

The only difference in the fatty acid composition of the diets was the higher content of 18:2n-6 (linoleic acid) and total n-6 in PP50 and PP75 diets that contributed to a higher contet in total PUFA in these 2 diets and was due to the high content of soy bean meal

	Experimental diets		
	FM	PP50	PP75
HyPro	0.43 ± 0.01 a	0.30 ± 0.02 b	0.28 ± 0.01 b
His	0.81 ± 0.01	0.76 ± 0.03	0.76 ± 0.01
Tau	0.25 ± 0.01 a	0.15 ± 0.03 b	0.10 ± 0.00 c
Ser	1.53 ± 0.01	1.63 ± 0.01	1.71 ± 0.04
Arg	2.32 ± 0.02	2.08 ± 0.05	2.08 ± 0.07
Gly	2.47 ± 0.02 a	2.13 ± 0.06 b	2.05 ± 0.04 b
Asp	3.16 ± 0.01 a	2.88 ± 0.03 b	2.72 ± 0.01 b
Glu	5.61 ± 0.07 c	7.51 ± 0.08 b	8.30 ± 0.07 a
Thr	1.49 ± 0.00 a	1.35 ± 0.02 b	1.31 ± 0.02 b
Ala	2.19 ± 0.02 a	2.07 ± 0.01 b	1.90 ± 0.01 c
Pro	1.82 ± 0.01 c	2.36 ± 0.03 b	2.64 ± 0.03 a
Cys	0.14 ± 0.01 c	0.20 ± 0.01 b	0.24 ± 0.01 a
Lys	2.58 ± 0.02 a	2.54 ± 0.04 a	2.34 ± 0.02 b
Tyr	0.96 ± 0.02	1.00 ± 0.05	1.12 ± 0.03
Met	0.84 ± 0.02	0.77 ± 0.01	0.83 ± 0.03
Val	1.74 ± 0.02 a	1.60 ± 0.03 b	1.57 ± 0.01 b
Ile	1.40 ± 0.02	1.37 ± 0.01	1.35 ± 0.03
Leu	2.59 ± 0.03 b	2.88 ± 0.01 a	2.97 ± 0.05 a
Phe	1.41 ± 0.01 b	1.53 ± 0.06 ab	1.76 ± 0.06 a

Differences in amino acid composition of the diets were less tan 5-10%, except for Glu. According to NRC (2011) the diets met in excess the nutritional requirements for fish in terms of essential amino acids.

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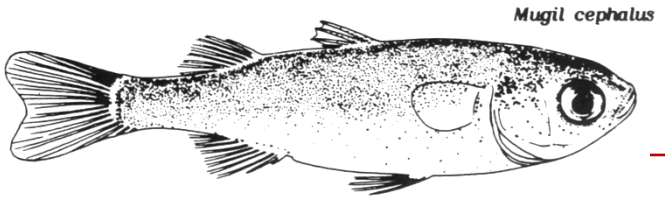
Samplings:



- *Growth performance*
  BW, SL (30 & 60 d)
- *Survival*

- *Histological organization of target tissues*
  Liver and intestine (60 d)
- *Maturation of the digestive functions*
  Activity of gastric and intestinal enzymes (30 & 60 d)
- *Proximate, fatty acid and amino acid composition*
  (30 & 60 d)

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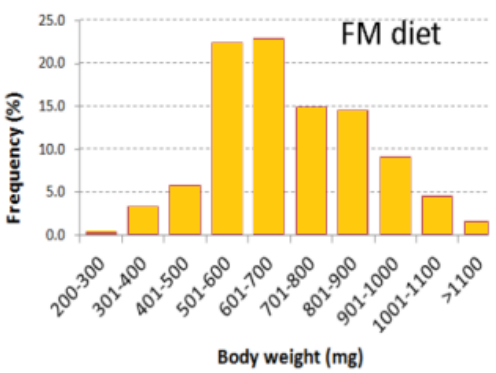
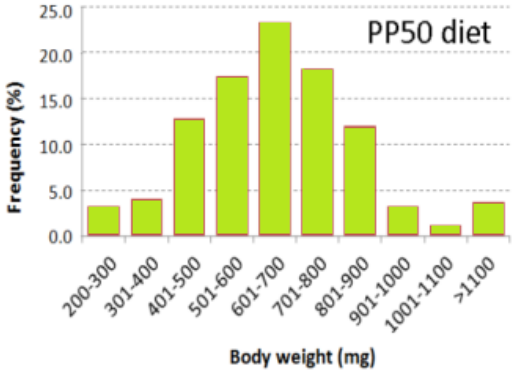
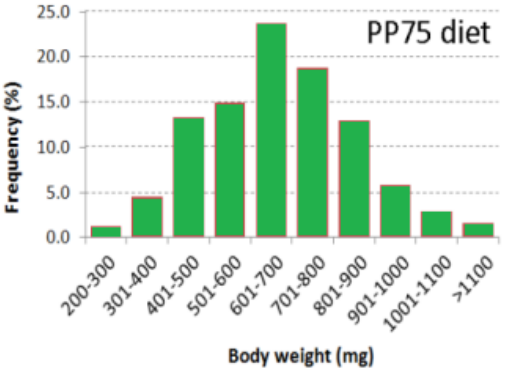
	Day 30 (end of the weaning)				
	BW (mg)	SL (mm)	K	SGR(%/day)	S (%)
Control	390 ± 15	2.5 ± 0.01	2.64 ± 0.06	1.9 ± 0.1	78.6 ± 5.1
PP50	385 ± 12	2.4 ± 0.02	2.72 ± 0.05	1.8 ± 0.1	73.4 ± 3.1
PP75	375 ± 18	2.4 ± 0.02	2.72 ± 0.05	1.9 ± 0.1	71.1 ± 4.2

	Day 60 (end of the trial)				
Control	707 ± 17	3.2 ± 0.02	2.17 ± 0.05	2.1 ± 0.05	74.6 ± 3.1
PP50	661 ± 10	3.1 ± 0.02	2.18 ± 0.04	1.9 ± 0.07	70.4 ± 4.2
PP75	681 ± 20	3.2 ± 0.02	2.17 ± 0.03	1.8 ± 0.09	69.1 ± 3.1

FM substitution by different plant proteins did not affect the growth in weight (BW) and length (SL), condition factor (K), growth rate or survival neather at weaning (30 days) nor at early ongrowing (60 days). The weaning schedule used had no detrimental effects on fish performance and condition







BW distribution at the end of the trial was more homogeneous in the fish fed PP50 and PP75 diets that on the fish fed FM

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	Day 30 (end of the weaning)			
	Protein (%DW)	Lipis (% DW)	Carbohydrates (% DW)	Ash (% DW)
Control	56.6 ± 1.1	26.2 ± 0.6	3.6 ± 0.1	4.8 ± 0.1
PP50	56.8 ± 1.7	26.5 ± 0.5	3.6 ± 0.1	3.9 ± 0.1
PP75	56.3 ± 1.1	26.0 ± 0.8	3.5 ± 0.1	4.2 ± 0.1
	Day 60 (end of the trial)			
Control	44.4 ± 0.9	34.5 ± 0.6	5.2 ± 0.05	3.0 ± 0.03
PP50	45.9 ± 1.1	32.8 ± 1.0	5.0 ± 0.13	3.2 ± 0.08
PP75	46.6 ± 1.0	32.5 ± 1.2	4.8 ± 0.13	3.2 ± 0.10

	Control	PP50	PP75
Total lipids (mg DW)	345 ± 6	328 ± 10	325 ± 12
Total Fatty acids (mg/g lipids)	634.1 ± 128.2	709.9 ± 162.1	675.5 123.9
Fatty Acids (mg/g lipids)			
16:0	110.5 ±6.3	116.8 ± 4.5	109.1 ± 2.0
Total Saturated (SFA)	**154.0 ± 6.3**	**161.9 ± 6.4**	**152.6 ± 3.0**
18:1n-9	17.0 ± 3.6	96.6 ± 5.8	102.0 ± 4.4
Total Monounsaturated (MUFA)	237.1 ± 10.5	263.9 ± 18.9	260.3 ± 9.4
18:2n-6	46.6 ± 2.2 b	66.6 ± 3.1 a	67.6 ± 1.0 a
20:4n-6 (ARA)	2.8 ± 0.2	2.4 ± 0.4	2.3 ± 0.3
Total n-6	51.6 ± 3.3 b	69.9 ± 4.1 a	72.0 ± 1.0 a
18:3n-3	10.3 ± 0.5	13.0 ± 1.1	12.3 ± 0.5
18:4n-3	13.6 ± 0.7	15.8 ± 0.81	15.6 ± 0.6
20:5n-3 (EPA)	47.6 ± 1.8	44.4 ± 2.1	44.8 ± 3.1
22:6n-3 (DHA)	71.7 ± 0.4	78.0 ± 3.3	77.3 ± 0.2
Total n-3	163.4 ± 4.4	179.3 ± 10.2	171.1 ± 10.6
Tota PUFA	215.0 ± 8.0	229.2 ± 13.1	231.1 ± 11.7

No differences in the proximate composition of the juveniles could be found neither at day 30 nor at day 60. Only protein showed a slight decrease between day 30 and 60 in parallel with a lipid increase probably due to the food change (Artemia replaced by feed) and fat accumulation in the juveniles at the end of the trial.

The fatty acid composition of th jvueniles reflected the composition of diets, with a significant difference in the content of linoleic acid (18:2n-6) and total n-6 due to the inclsion of plant proteins. No differences could be found in the levels of n-3 PUFA due to the high content of fish oil in the diets

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Day 60 (end of the trial)			
	FM diet	PP50 diet	PP75 diet
HyPro	0.08 ± 0.01	0.10 ± 0.01	0.09 ± 0.00
His	0.47 ± 0.01	0.46 ± 0.03	0.42 ± 0.01
Tau	0.37 ± 0.01	0.38 ± 0.02	0.37 ± 0.01
Ser	0.69 ± 0.01	0.70 ± 0.01	0.69 ± 0.00
Arg	0.98 ± 0.01	0.99 ± 0.03	0.98 ± 0.01
Gly	0.83 ± 0.01	0.86 ± 0.01	0.84 ± 0.01
Asp	1.66 ± 0.04	1.62 ± 0.01	1.63 ± 0.01
Glu	2.41 ± 0.03	2.35 ± 0.03	2.37 ± 0.03
Thr	0.72 ± 0.01	0.72 ± 0.01	0.71 ± 0.01
Ala	1.04 ± 0.02	1.03 ± 0.02	1.03 ± 0.01
Pro	0.63 ± 0.00	0.66 ± 0.01	0.65 ± 0.01
Cys	0.07 ± 0.00	0.07 ± 0.00	0.07 ± 0.01
Lys	1.54 ± 0.03	1.48 ± 0.04	1.48 ± 0.03
Tyr	0.49 ± 0.01	0.49 ± 0.02	0.48 ± 0.00
Met	0.45 ± 0.01	0.43 ± 0.01	0.43 ± 0.01
Val	0.80 ± 0.01	0.81 ± 0.01	0.80 ± 0.02
Ile	0.68 ± 0.01	0.68 ± 0.01	0.68 ± 0.02
Leu	1.26 ± 0.02	1.26 ± 0.02	1.25 ± 0.02
Phe	0.65 ± 0.01	0.67 ± 0.03	0.65 ± 0.01

No differences could be found in the amino acid profile of the fish at the end of the trial.

The specific activity (mU/mg protein) of pancreatic and intestinal digestive enzymes didn't show any difference among the groups, neither did the antioxidative stress enzymes (data not shown)

Day 60 (end of the trial)			
	FM diet	PP50 diet	PP75 diet
Exocrine pancreas			
Total alkaline proteases	3.70 ± 0.32	3.70 ± 0.19	3.51 ± 0.17
Trypsin	0.71 ± 0.13	0.81 ± 0.05	0.81 ± 0.07
Lipase	31.6 ± 8.97	26.6 ± 4.31	26.2 ± 3.43
α-amylase	23.6 ± 6.83	17.0 ± 3.51	20.5 ± 2.39
Intestine			
Alkaline phosphatase (AP)	2.9 ± 0.65	2.3 ± 0.86	4.1 ± 0.68
Aminopeptidase-N (AN)	0.05 ± 0.004	0.06 ± 0.009	0.04 ± 0.006
Maltase	1.56 ± 0.50	2.16 ± 0.31	2.04 ± 0.17
Leucine alanine peptidase (LAP)	717 ± 131	849 ± 104	845 ± 141
Intestinal maturation indexes		0	
AP/LAP	4.4 ± 1.1	2.9 ± 0.8	5.1 ± 1.4
AN/LAP	0.07 ± 0.01	0.06 ± 0.01	0.08 ± 0.02

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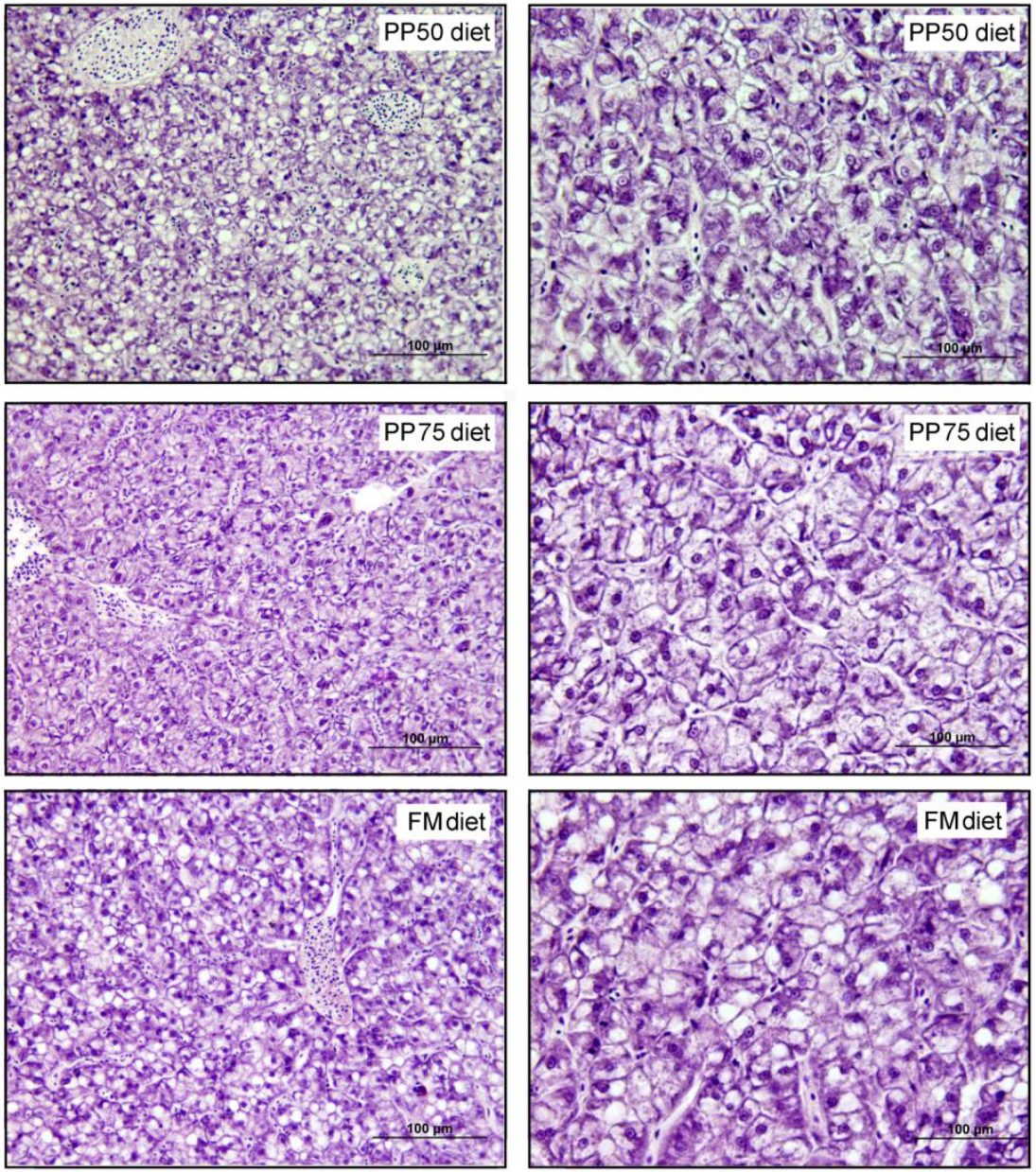

No major changes in the histological organization were found in the liver of fish weaned using the experimental diets, they showed a healthy liver with a moderate accumulation of fat deposits and glycogen within hepatocytes, without any sign of hepatic steatosis.

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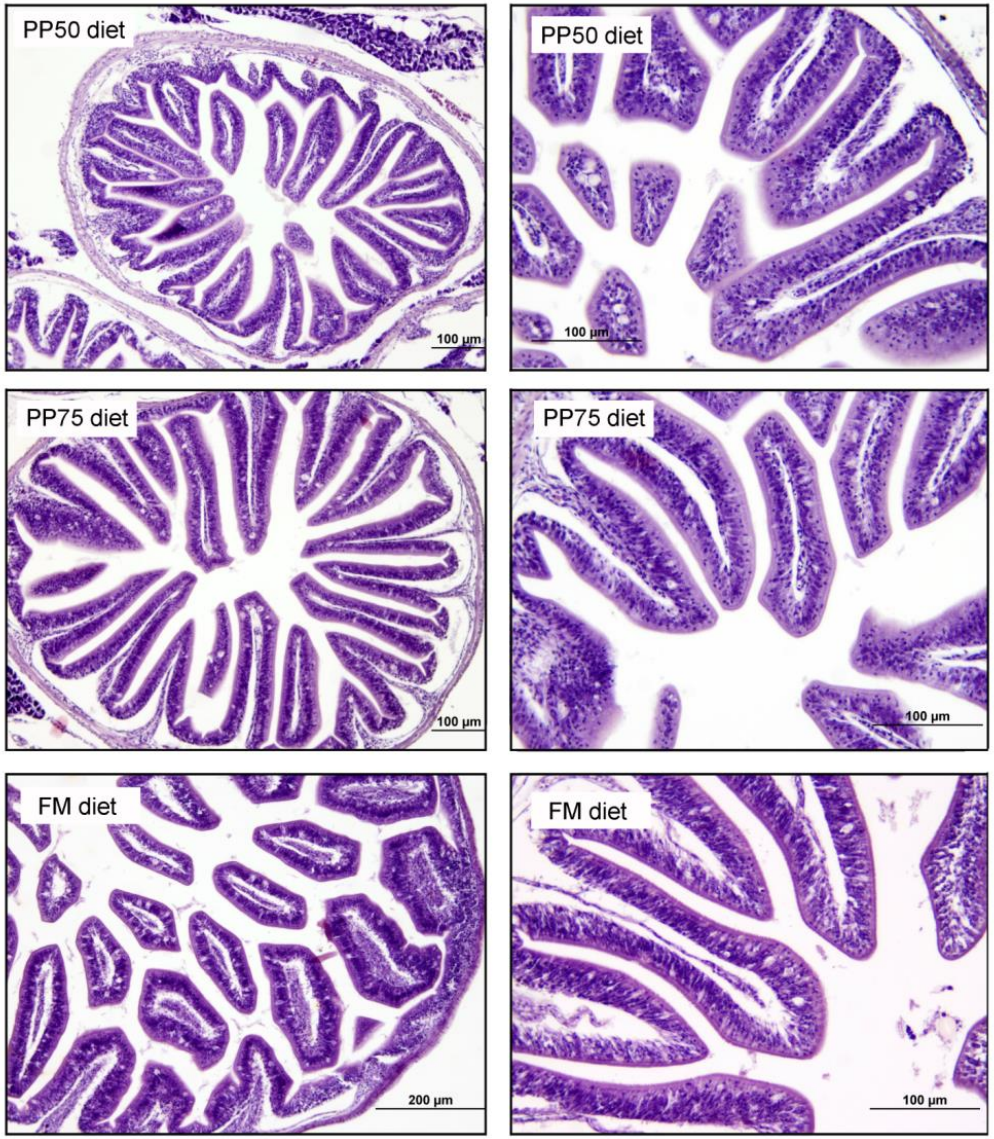

No major changes were observed in the intestine of the fish fed the experimental diets. Different regions of the gut showed prominent villi with a moderate number of goblet cells in the epithelium. Lipid accumulation within enterocytes was negligible and no signs of epithelial abrasion or microvilli disarrangement were obsrved along different intestinal regions

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Conclusions

1. FM substitution with different plant protein sources at 50 and 75% did not affect growth performance and survival of grey mullet . The weaning strategy used for wild grey mullet using these diets was correct in terms of growth and survival.

2. The growth rats obtained were similar to those reported by other authors and confirm the capacity of grey mullet to digest plant protein sources at early life stages.

3. No differences in the proximate, fatty acids and amino acid composition were found among the fish fed the experimental diets. The same can be said regarding the digestive capacity, the activity of pancreatic and intestinal enzymes was not affected by the diet composition.

4. Weaning diets for wild grey mullet can be formulated with a high level of FM replacement by alternative plant protein sources.

5. It seems plausible that juveniles of this species may accept and use compound diets with a complete FM substitution by plant protein sources.

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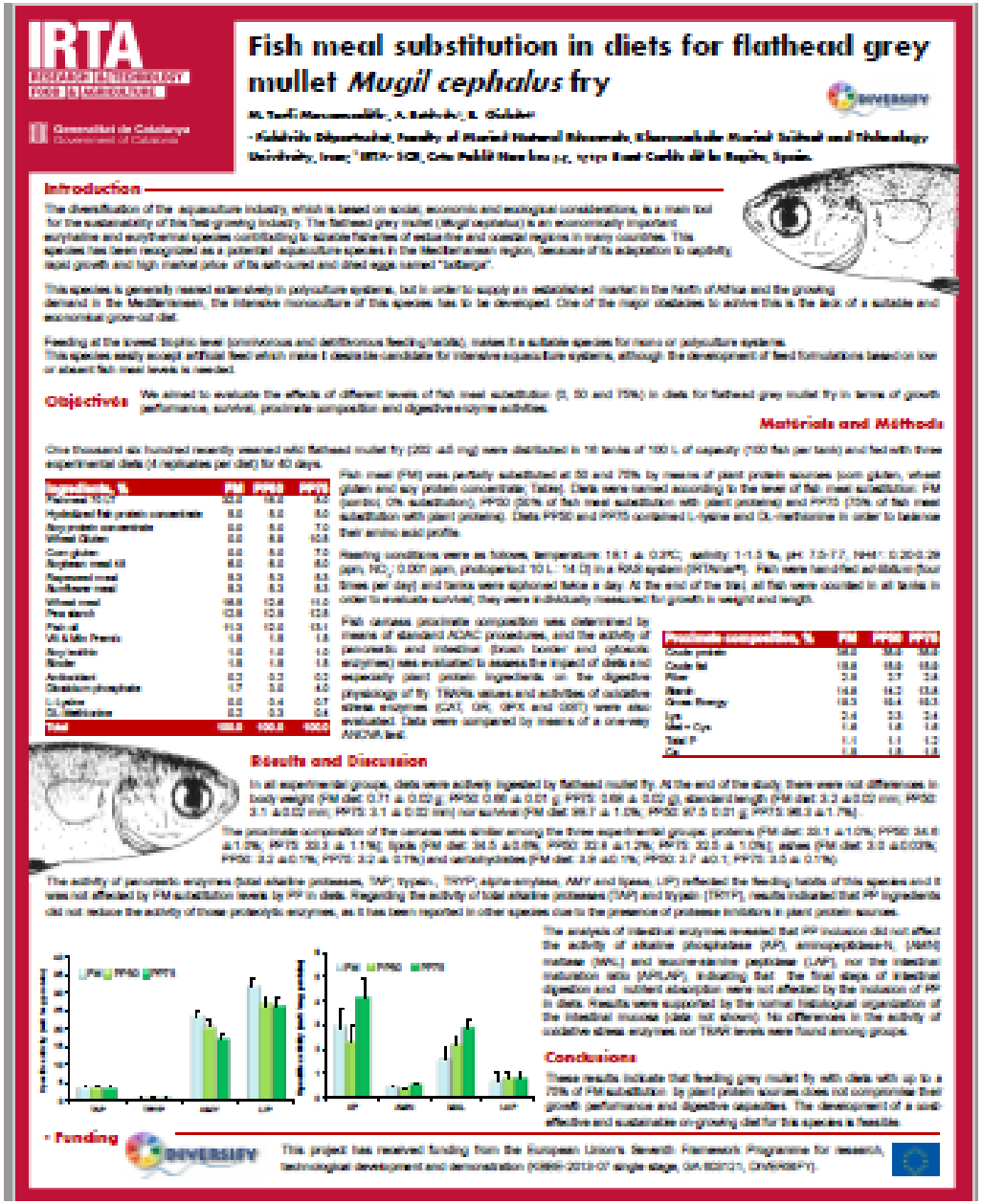

Fish meal substitution in diets for flathead grey mullet *Mugil cephalus* fry

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Introduction

The diversification of the aquaculture industry, which is based on social, economic and ecological considerations, is a main tool for the sustainability of this fast-growing industry. The flathead grey mullet (*Mugil cephalus*) is an economically important euryhaline and eurythermal species contributing to sizable fisheries of estuarine and coastal regions in many countries. This species has been recognized as a potential aquaculture species in the Mediterranean region, because of its adaptation to captivity, rapid growth and high market price of its salt-cured and dried eggs named "bottarga".

This species is generally reared extensively in polyculture systems, but in order to supply an established market in the North of Africa and the growing demand in the Mediterranean, the intensive monoculture of this species has to be developed. One of the major obstacles to achieve this is the lack of a suitable and economical grow-out diet.

Feeding at the lowest trophic level (omnivorous and detritivorous feeding habits), makes it a suitable species for mono or polyculture systems. This species easily accept artificial feed which make it desirable candidate for intensive aquaculture systems, although the development of feed formulations based on low or absent fish meal levels is needed.

Objectives

We aimed to evaluate the effects of different levels of fish meal substitution (0, 50 and 75%) in diets for flathead grey mullet fry in terms of growth performance, survival, proximate composition and digestive enzyme activities.

Materials and Methods

One thousand six hundred recently weaned wild flathead mullet fry (200 ±45 mg) were distributed in 16 tanks of 100 L of capacity (100 fish per tank) and fed with three experimental diets (4 replicates per diet) for 40 days.

Ingredients, %	FM	PP50	PP75
Fishmeal 70CP	55.0	18.0	8.0
Hydrolyzed fish protein concentrate	8.0	8.0	8.0
Soy protein concentrate	8.0	8.0	7.0
Wheat Gluten	8.0	8.0	10.0
Corn gluten	8.0	8.0	7.0
Soybean meal 48	8.0	8.0	8.0
Rapeseed meal	8.3	8.3	8.3
Sunflower meal	8.3	8.3	8.3
Wheat meal	16.8	12.8	11.0
Pea starch	12.8	12.8	12.8
Fish oil	11.3	12.0	13.1
Vit & Min Premix	1.8	1.8	1.8
Soy lecithin	1.0	1.0	1.0
Binder	1.8	1.8	1.8
Antioxidant	0.2	0.2	0.2
Dicalcium phosphate	1.7	3.0	4.0
L-Lysine	0.0	0.4	0.7
DL-Methionine	0.2	0.3	0.4
Total	100.0	100.0	100.0

Fish meal (FM) was partially substituted at 50 and 75% by means of plant protein sources (corn gluten, wheat gluten and soy protein concentrate; Table). Diets were named according to the level of fish meal substitution: FM (control), 0% substitution), PP50 (50% of fish meal substitution with plant proteins) and PP75 (75% of fish meal substitution with plant proteins). Diets PP50 and PP75 contained L-lysine and DL-methionine in order to balance their amino acid profile.

Rearing conditions were as follows, temperature: 18.1 ± 0.3°C; salinity: 1-1.5 ‰; pH: 7.5-7.7; NH4+: 0.20-0.29 ppm; NO_2^-: 0.001 ppm, photoperiod: 10 L : 14 D) in a RAS system (INTAhab®). Fish were hand-fed ad-libitum (four times per day) and tanks were siphoned twice a day. At the end of the trial, all fish were counted in all tanks in order to evaluate survival; they were individually measured for growth in weight and length.

Fish carcass proximate composition was determined by means of standard AOAC procedures, and the activity of pancreatic and intestinal (brush border and cytosolic enzymes) was evaluated to assess the impact of diets and especially plant protein ingredients on the digestive physiology of fly. TRAPs values and activities of oxidative stress enzymes (CAT, GR, GPX and GST) were also evaluated. Data were compared by means of a one-way ANOVA test.

Proximate composition, %	FM	PP50	PP75
Crude protein	58.0	58.0	58.0
Crude fat	18.8	18.8	18.8
Fiber	2.8	2.7	2.8
Starch	14.8	14.3	13.8
Gross Energy	18.5	18.4	18.3
Ash	2.4	2.3	2.4
P_{2O_5} - Cys	1.8	1.8	1.8
Total P	1.1	1.1	1.2
Ca	1.8	1.8	1.8

Results and Discussion

In all experimental groups, diets were actively ingested by flathead mullet fry. At the end of the study there were not differences in body weight (FM diet: 0.71 ± 0.02 g; PP50: 0.68 ± 0.01 g; PP75: 0.69 ± 0.02 g), standard length (FM diet: 3.2 ±0.02 mm; PP50: 3.1 ±0.02 mm; PP75: 3.1 ± 0.02 mm) nor survival (FM diet: 99.7 ± 1.0%; PP50: 97.5 ± 0.01 g; PP75: 96.3 ± 1.7%).

The proximate composition of the carcass was similar among the three experimental groups: proteins (FM diet: 59.1 ±1.0%; PP50: 56.8 ±1.0%; PP75: 59.3 ± 1.1%); lipids (FM diet: 34.5 ±0.8%; PP50: 32.8 ±1.2%; PP75: 32.5 ± 1.0%); ashes (FM diet: 3.0 ±0.03%; PP50: 3.2 ±0.1%; PP75: 3.2 ± 0.1%) and carbohydrates (FM diet: 3.8 ±0.1%; PP50: 3.7 ±0.1; PP75: 3.0 ± 0.1%).

The activity of pancreatic enzymes (total alkaline proteases, TAP; trypsin-, TRYP; alpha-amylase, AMY and lipase, LIP) reflected the feeding habits of this species and it was not affected by FM substitution levels by PP in diets. Regarding the activity of total alkaline proteases (TAP) and trypsin (TRYP), results indicated that PP ingredients did not reduce the activity of those proteolytic enzymes, as it has been reported in other species due to the presence of protease inhibitors in plant protein sources.

The analysis of intestinal enzymes revealed that PP inclusion did not affect the activity of alkaline phosphatase (AP), aminopeptidase-N, (AMN) maltase (MAL) and leucine-alanine peptidase (LAP), nor the intestinal maturation ratio (AP/LAP), indicating that the final steps of intestinal digestion and nutrient absorption were not affected by the inclusion of PP in diets. Results were supported by the normal histological organization of the intestinal mucosa (data not shown). No differences in the activity of oxidative stress enzymes nor TRAP levels were found among groups.

Conclusions

These results indicate that feeding grey mullet fry with diets with up to a 75% of FM substitution by plant protein sources does not compromise their growth performance and digestive capacities. The development of a cost-effective and sustainable on-growing diet for this species is feasible.

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Weaning wild flathead grey mullet (*Mugil cephalus*) fry with diets with different levels of fish meal substitution

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ABSTRACT

The culture of flathead grey mullet (*Mugil cephalus*) is based on wild fry captured during their migration into estuarine environments and consequently, optimizing weaning diets is of special importance for this species at this particular stage of development. Thus, authors have tested a weaning protocol for wild flathead grey mullet fry (202 mg initial body weight) during 60 days (18.1 ± 0.3 °C, salinity, 1.2 ± 0.2‰) using compound diets (36% crude protein, 16% crude fat) with different levels of fish meal (FM) substitution by plant protein (PP) sources (50% and 75% of FM replacement by a blend of corn gluten, wheat gluten, soy bean meal and soy protein concentrate). Fry were progressively weaned onto experimental diets during the first 20 days of the trial (25% *Artemia* metanauplii replacement each 5 days), whereas compound diets were offered at a feed ratio of 5% of stocked biomass until the end of the trial (day 60). A blend of PP sources (corn gluten, wheat gluten and soy protein concentrate) as the main dietary protein sources in combination with crystalline L-lysine and DL-methionine dietary supplementation were as good as a FM-based diet in terms of growth performance, digestive physiology and fish condition (*i.e.* proximate composition, oxidative stress status). As the cost-benefit proxy analysis of the tested weaning diets indicated, the inclusion of alternative PP was a satisfactory strategy in terms of feed price reduction, since PP50 and PP75 diets were 15.5 and 23.6% cheaper than the FM diet. Although wild flathead grey mullet fry were satisfactorily weaned onto diets containing 75% FM substitution by PP sources, present results indicated that complete FM replacement in weaning diets for this species might also be feasible.

Statement of relevance: In this study, authors have tested a weaning protocol for wild flathead grey mullet (*Mugil cephalus*) fry based on diets with different levels of fish meal substitution by alternative plant protein sources. This is of special importance due to the importance of the aquaculture of this species in several regions of the word, as well as for the use of wild animals for on-growing purposes. Results showed that diets with 75% of fish meal substitution can be successfully used for weaning and on-growing wild fry without any detrimental effect of fry performance and condition.

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Deliverable Report

Deliverable No:	D23.1	**Delivery Month:**	22
Deliverable Title	Cost-effective weaning strategies for wild-caught grey mullet grow out and their effect on growth and health status		
WP No:	23	**WP Lead beneficiary:**	P4
WP Title:	Grow out husbandry – grey mullet		
Task No:	23.1	**Task Lead beneficiary:**	P3
Task Title:	Determine the cost-benefit of different weaning diets on the performance and health status of wild juveniles.		
Other beneficiaries:	P3. IRTA		
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Lead Scientist preparing the Deliverable: Gisbert, E. (IRTA)

Other Scientists participating: Estévez, A. (IRTA); Kotzamanis, Y. (HCMR)

Objective: The objective of this Deliverable was to determine the cost-benefit of different weaning diets on the performance and health status of grey mullet fry.

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Deliverable submitted and uploaded on November 2016

Gracias por su atención

Thanks for your attention

Merci beaucoup pour votre attention

Grazie mille per la vostra attenzione

Vielen dank für ihre aufmerksamkeit

Bedankt voor uw aandacht