ICES CM 2000/P:01

FISH MEAL/FISH OIL REPLACEMENT IN PRACTICAL DIETS FOR EUROPEAN SEABASS *Dicentrarchus labrax* AND GILTHEAD SEABREAM *Sparus aurata*

P. Coutteau[1], S. Ceulemans[1], R. Robles[2], A. Oliva-Teles[3], S. Chatzifotis[4], A. Van Halteren'and P. Verstraete[1].

[1] INVE TECHNOLOGIES N.V. · Oeverstraat 7 B-9200 Baasrode Belgium
[2] Depattamento de Biologia Animal Biologia Vegetal y Ecología Facultad de Ciencias del Mar Universidad de Cádiz Poligono Rio San Pedro s/n E-11510 Puerto Real-Cádiz · Spain
[3] Departamento de Zoologia e Antropologia e CIMAR · Faculdade de Ciencias do Porto 4050 Oporto Portugal
[4] Institute of Marine Biology of Crete PO BOX 2214 71003 Heraklion · Greece

ICES CM 20

FISH MEAL/FISH OIL REPLACEMENT IN PRACTICAL DIETS FOR EUROPEAN SEABASS

P. Coutteau[1], S. Ceulemans[1], R. Robles[2], A. Oliva-Teles[3], S. Chatzifotis[4], A.

1 INVE TECHNOLOGIES N." Oeverstraat 7 B-9200 Baasrode Be
2 Departamento de Biologia Animal Biologia Vegetal y Ecología Fac
3 Departamento de Zoologia e Antropologia e CIMAR - Faculdade de
4 Institute of Marine Biology of Crete PO BOX 2214 71003 Heraklior

INTRODUCTION

The substitution of fish meal (FM) and fish oil (FO) in aquafeeds remains an important issue:

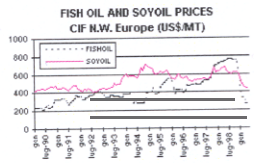
- Fisheries resources will be a bottle-neck for the increase of aquafeed production in the future
- Supply and price of FM/FO is highly variable
- Dioxine and pesticide restrictions
- Organic farming

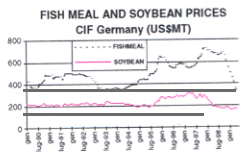
Alternate protein sources originating from cereals, soybean, and terrestrial animal by-products have great potential for replacing FM/FO in aquafeeds, but also show some drawbacks:

- Unstable end-consumer acceptance (BSE, GMO, dioxine,...)
- Limited information for practical feed formulation (cost-efficiency compared with FM/FO; raw material quality and selection; inclusion restrictions; need for the supplementation of essential nutrients; effects on palatibility, ...)

The present study evaluated the reduction of fish meal and fish oil in practical feed formulations for European seabass down to 1/4 of dietary protein and 1/3 of dietary fat. This degree of replacement is relatively high compared to today's practice (*eg* 60-80% of protein from fish meal), whereas replacement beyond this level may not be cost-effective in practice.

Price variation for fish/soybean oil and fish meal/soybean (source: FAO)





TRIAL A: Partial replacement of fish meal protein with vegetal protein

OBJECTIVE

Reduce the **fish meal** level in a practical feed for sea bass from 66 to 25% of dietary protein by

- the use of **vegetal** protein sources (soybean products, corngluten)
- **nutritional compensation** of possible essential nutrients lost by the fish meal replacement (amino acids, minerals, vitamins, phospholipids, highly unsaturated fatty acids, attractive substances)

Evaluate the effects on culture performance and carcass composition

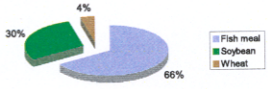
FEEDS

CONTROL FEED (FM66)

= high performance, practical feed formulation for sea bass

- **66% fish meal protein**
- **standard premix** supplementing minerals, vitamins, essential amino acids, phospholipids

Protein composition FM66



EXPERIMENTAL FEED (FM25-VEG)

- **25% fish meal protein**, the remaining from **vegetal** sources, mainly soybean meal and corn gluten
- **specialty premix** compensating possible nutrients lost due to the fish meal replacement (essential amino acids, attractants, minerals, vitamins, phospholipids, highly unsaturated fatty acids)

Protein composition FM25-VEG

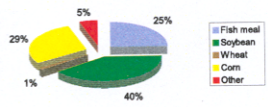


Table A1: Formulation of the feeds (Trial A)

	FM66	FM25-VEG
Standard fish meal	44.9	17.3
Tobish oil	8.8	8.8
Soybean protein concentrate	4.3	25.6
Defatted soybean meal	16.8	-
Fullfat soybean meal	8.7	9.6
Wheatflour	12.5	5.2
Corngluten	-	21.5
Standard premix[1]	4.0	-
Specialty premix[2]	-	12.0
Total	100	100

[1] contains essential amino acids, available phosphorous, trace minerals, vitamins, phospholipids, filler
[2] contains essential amino acids, available phosphorous, macro & trace minerals, vitamins, phospholipids, highly unsaturated fatty acids, attractants, filler

Table A2: Proximate composition of the feeds (Trial A)

%	FM66	FM25-VEG
Moisture	3.0	3.9
Ash	10.6	11.5
Crude protein	50.9	49.7
Crude fat (after hydrolysis)	15.6	16.6
Starch	9.9	9.5
Crude fibre	1.3	1.3

EXPERIMENTAL CONDITIONS

- 50 sea bass of 5.5 g / 250 L tank
- partial recirculation
- 20.7 °C +- 0.7; 34+- 1 ppt salinity
- duration: 70 days
- fed to apparent satiation 2 times/day

RESULTS

Juvenile sea bass fed FM25-VEG versus the control feed FM66 for 70 days showed

- no significant difference in performance (SGR 1.9-2.0%/day; FCR 1.1; PER 1.7-1.8; **Table A3**)
- no significant difference in total carcass analysis (moisture 66%; protein 17.7%; fat 12.2%; ash 4.2-4.3%; **Fig. A1**)
- no difference in nitrogen retention (30% of N intake; **Table A4**)

Fig A1: Total carcass analysis of initial (one sample) and final fish (data represent average and standard deviation from triplicate analyses; no significant differences between means, t-test P<0.05).

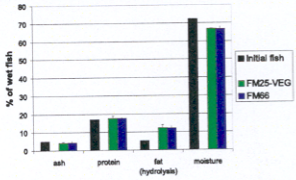


Table A3: Growth and feed utilization of sea bass juveniles fed the experimental diets for 70 days (means and standard deviation from triplicate tanks; no significant difference between treatment means, t-test P<0.05).

	FM66	FM25-VEG
Initial weight (g)	5.6 ± 0.0	5.6 ± 0.0
Final weight (g)	21.8 ± 1.1	20.8 ± 0.5
Weight gain (g/kg ABW/day) (1)	17.1 ± 0.5	16.6 ± 0.2
Specific growth rate (%/day) (2)	1.95 ± 0.07	1.89 ± 0.04
Feed intake (dry feed as %ABW/day)	1.90 ± 0.01	1.90 ± 0.03
Feed conversion (dry feed basis) (3)	1.08 ± 0.02	1.11 ± 0.02
Protein efficiency ratio (4)	1.77 ± 0.04	1.73 ± 0.04

Survival 100% in all treatments

(1)Average body weight (ABW): (initial body weight + final body weight)/2
(2)SGR (%) : (ln final weight - ln initial weight) x 100 / time (days)
(3)FC: dry feed intake / fresh weight gain
(4)PER: fresh weight gain / crude protein intake

Table A4: Nitrogen balance in sea bass fed the experimental diets for 70 days.

PROTEIN RETENTION	FM66	FM25-VEG
Initial weight	5.6	5.6
Initial protein content (%)	17.1	17.1
Final weight (g)	21.8	20.8
Final protein content (%)	17.7	17.7
Protein gain/ind (g)	2.9	2.7
Feed intake/ind (g dry matter)	18.2	17.6
Dietary protein content (% dry matter)	52.5	51.7
Protein intake/ind (g)	9.6	9.1
Protein retention (%)	30	30

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ASS *Dicentrarchus labrax* AND GILTHEAD SEABREAM *Sparus aurata*

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de Belgium
a Facultad de Ciencias del Mar Universidad de Cádiz Poligono Rio San Pedro sin E-11.510 Puerto Real-Cádiz Spain
de de Ciencias do Porto 4050 Oporto Portugal
eraklion Greece

FEED FORMULATION & PREPARATION

Practical feeds for European sea bass (48/17 crude protein/crude fat after hydrolysis ; Tables A1 & B1) were formulated using the Least Cost Formulation software "Bestmix" (Adifo N.V., Belgium). Pellets (2 mm diameter) were extruded on a co-rotating twin-screw extruder Clextral BC45. Up to 6% of the oils was coated on the pellets after drying.

CONCLUSIONS

The proportion of **fish meal protein** in nutritionally balanced feeds for European sea bass could be reduced from 66% (of total dietary protein) to **25%** by the use of either pure vegetal protein sources (soybean, corn) or a mixture of vegetal (soybean, wheat) and animal meals (poultry meal, haemoglobin).

The proportion of **fish oil/meal fat** could be reduced from 81% (of total dietary fat) to **33%** by the use of a mixture of predominantly vegetal (soybean) and animal fat (poultry meal).

This replacement did not affect **growth** performance, **food conversion** and total **carcass proximate analysis** in laboratory trials.

Further studies are needed to verify the effects on performance and flesh quality in long-term ongrowing studies under farm conditions.

TRIAL B : Partial replacement of fish meal/fish oil with vegetal and animal protein/fat sources

OBJECTIVES

Reduce in a practical feed for sea bass
- the **fish meal** level from 66 to 25% of dietary protein
- the **fish oil** level from 81 to 33% of dietary fat

By
- the use of **vegetal** (soybean products, wheat gluten) and **animal** protein/fat sources (poultry meal, haemoglobine powder)
- **nutritional compensation** of essential nutrients lost by the fish meal replacement (amino acids, minerals, vitamins, phospholipids)

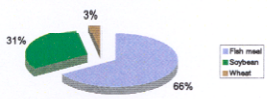
Evaluate the effects on culture performance and carcass composition

FEEDS

CONTROL FEED (FM66/FO81)

= high performance, practical feed formulation for sea bass
- **66% of dietary protein and 81% of dietary fat supplied by FO/FM**
- **standard premix** supplementing minerals, vitamins, essential amino acids and phospholipids

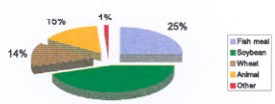
Protein composition FM66/FO81



EXPERIMENTAL FEEDS

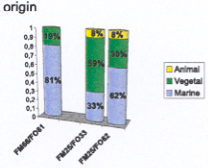
- **FISH MEAL REPLACEMENT: FM25-VEG/AN**
  25% fish meal protein, the remaining from **vegetal** (soybean & wheat) and **animal** sources (poultry meal & haemoglobine powder)

Protein composition FM25/FO33&62



- **FISH OIL REPLACEMENT: FO33 vs FO62**
  either **33 or 62% of the dietary fat supplied by FO/FM**, the remaining from **vegetal** (soybean oil) and **animal** sources (poultry meal)

Fat origin



- **NUTRITIONAL COMPENSATION**
  A specialty premix was formulated to compensate possible nutrients lost due to the fish meal replacement (essential amino acids, available phosphorous, macro and trace minerals, vitamins, phospholipids)

Table B1: Formulation of the feeds (Trial B)

	FM66/FO81	FM25/FO33	FM25/FO66
Standard fish meal	43.8	16.8	16.8
Tobish oil	7.8	2.6	7.6
Soybean oil	-	5.0	-
Wheat gluten	-	6.5	6.5
Wheat flour	10.8	8.7	8.7
Soybean protein concentrate	3.9	23.3	23.3
Defatted soybean meal	16.8	-	-
Fullfat soybean meal	11.9	18.9	19.0
Poultry meal	-	8.0	8.0
Haemoglobin powder	-	2.0	2.0
Standard premix[1]	5.0	-	-
Specialty premix[2]	-	8.1	8.1
Total	100	100	100

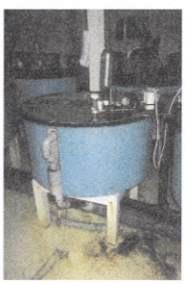
1 contains essential amino acids, available phosphorous, trace minerals, vitamins, phospholipids, filler
2 contains essential amino acids, available phosphorous, macro & trace minerals, vitamins, phospholipids, filler

Table B2: Proximate composition of the feeds (Trial B)

	FM66/FO81	FM25/FO33	FM25/FO66
Moisture	5.8	5.4	6.2
Ash	11.2	11.0	10.5
Crude Protein	48.4	49.0	49.0
Crude fat (after hydrolysis)	17.0	16.4	16.4
Crude fibre	1.4	1.7	1.6

EXPERIMENTAL CONDITIONS

- 100 sea bass of 5 g / 500 L tank
- partial recirculation
- 22-27°C; 38-40 ppt salinity
- duration: 95 days (feed intake quantified only during last 67 days)
- fed by means of self-feeders



RESULTS

Juvenile sea bass fed FM25/FO33 and FM25/FO66 versus the control feed FM66/FO81 for 95 days showed
- no significant difference in performance
  (SGR 2.4%/day; FCR 1.1; PER 1.7-1.8; **Table B3**)
- no significant difference in total carcass analysis, except for the higher water content in fish fed the lowest level of fish oil (FM25/FO33)
  (moisture 65-67%; protein 16.0-16.2%; fat 11.5-13.3%; ash 3.9-4.1%; **Fig. B1**)
- lower nitrogen retention efficiency, particularly in the treatment with the lowest level of fish oil (FM25/FO33: 30% versus 38% retained of N intake for the control feed; **Table B4**)

Fig B1: Total carcass analysis of initial (one sample) and final fish (data represent average and standard deviation from triplicate analyses; the only significant difference between means is denoted with * above respective bars, ANOVA Tukey HSD P<0.05).

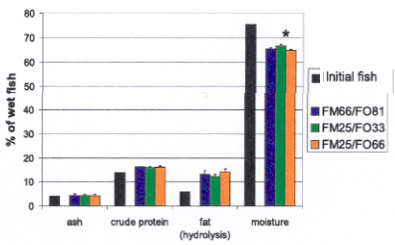


Table B3: Growth and feed utilization of sea bass juveniles fed the experimental diets for 95 days (means and standard deviation from triplicate tanks; no significant differences between treatment means, ANOVA Tukey HSD P<0.05).

	FM66/FO81	FM25/FO33	FM25/FO66
Initial weight (g)	4.9 ± 0.1	4.9 ± 0.1	4.8 ± 0.1
Final weight (g)	49.7 ± 2.8	47.6 ± 3.1	47.8 ± 3.2
Weight gain (g/kg ABW/day) (1)	17.3 ± 0.2	17.1 ± 0.2	17.2 ± 0.2
Specific growth rate (%/day) (2)	2.44 ± 0.08	2.40 ± 0.06	2.41 ± 0.06
Feed intake (dry feed as % ABW/day) (5)	1.95 ± 0.04	1.97 ± 0.05	2.07 ± 0.21
Feed conversion (dry feed basis) (3, 5)	1.08 ± 0.02	1.09 ± 0.03	1.13 ± 0.11
Protein efficiency ratio (4, 5)	1.80 ± 0.02	1.78 ± 0.04	1.70 ± 0.15

Survival >97% in all treatments
(1) Average body weight (ABW): (initial body weight + final body weight)/2
(2) SGR (%) : (ln final weight - ln initial weight) x 100 / time (days)
(3) FC: dry feed intake / fresh weight gain
(4) PER: fresh weight gain / crude protein intake
(5) Data on feed intake are based on the last 67 days of the trial

Table B4: Nitrogen balance in sea bass fed the experimental diets for 67 days.

	FM66/FO81	FM25/FO33	FM25/FO66
Initial weight (g)	4.9	4.9	4.8
Initial protein content (%)	13.9	13.9	13.9
Final weight (g)	49.7	47.6	47.8
Final protein content (%)	16.2	16.0	16.0
Protein gain/ind (g)	7.4	6.9	7.0
Feed intake/ind (g dry matter)	37.8	38.7	43.8
Dietary protein content (% dry matter)	51.4	51.8	52.2
Protein intake/ind (g)	19.4	20.1	22.9
Protein retention (%)	38	35	30