Promoting Cost-Effective Feeds Made with Locally Available Ingredients for a Sustainable Aquaculture

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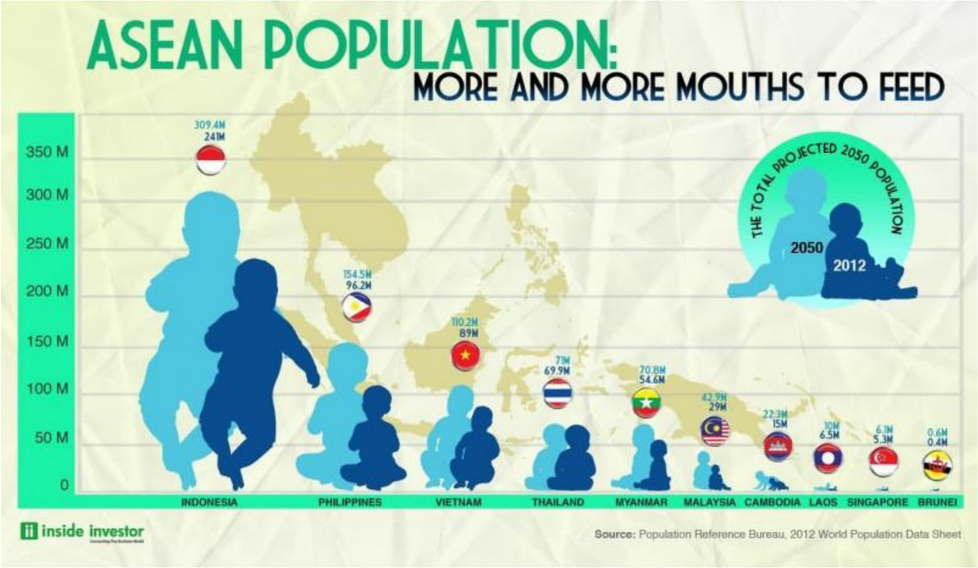
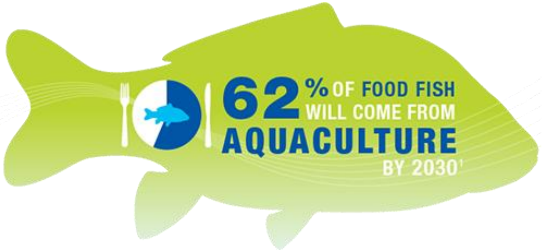
Sustainable aquaculture in a growing population?





Contribution of Asian countries in fish production (1)

Finfish- Inland Aquaculture (Top 10 Producers)		
China	**24 817 311**	**60.10%**
India	**4 148 407**	**10.00%**
Indonesia	**2 459 418**	**6.00%**
Vietnam	**2 369 903**	**5.70%**
Bangladesh	1 647 827	4.00%
Egypt	1 091 688	2.60%
Myanmar	**869 384**	**2.10%**
Thailand	**467 249**	**1.10%**
Brazil	388 700	0.90%
Philippines	**318 798**	**0.80%**
Others	2 713 481	6.60%
WORLD	**41 292 167**	**100%**

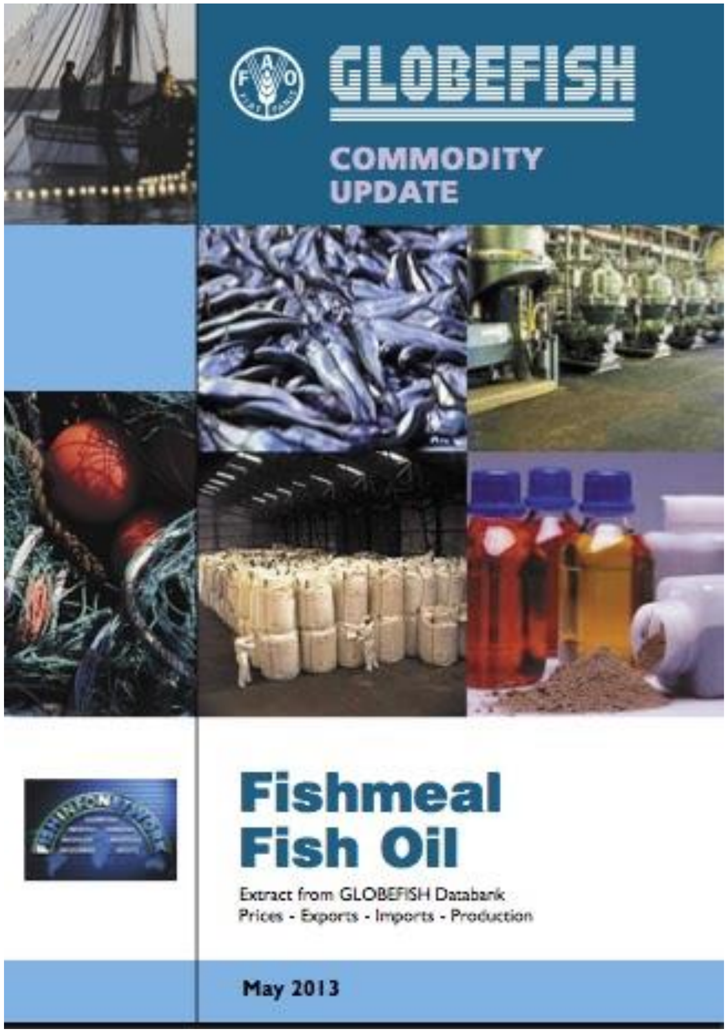
FAO, 2015

Contribution of Asian countries in fish production (2)

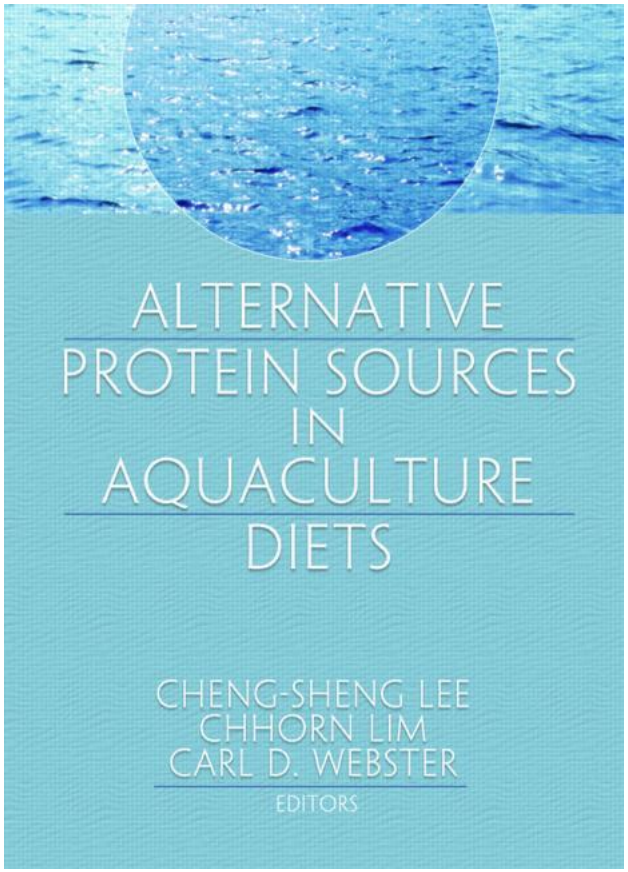
Finfish- Mariculture (Top 10 Producers)		
Norway	1 245 399	21.60%
China	**1 123 576**	**19.40%**
Chile	736 310	12.70%
Indonesia	**720 545**	**12.50%**
Philippines	**375 735**	**6.50%**
Japan	**242 905**	**4.20%**
United Kingdom	156 220	2.70%
Greece	124 740	2.20%
Canada	122 024	2.10%
Turkey	110 845	1.90%
Others	820 088	14.20%
WORLD	**5 778 387**	**100%**

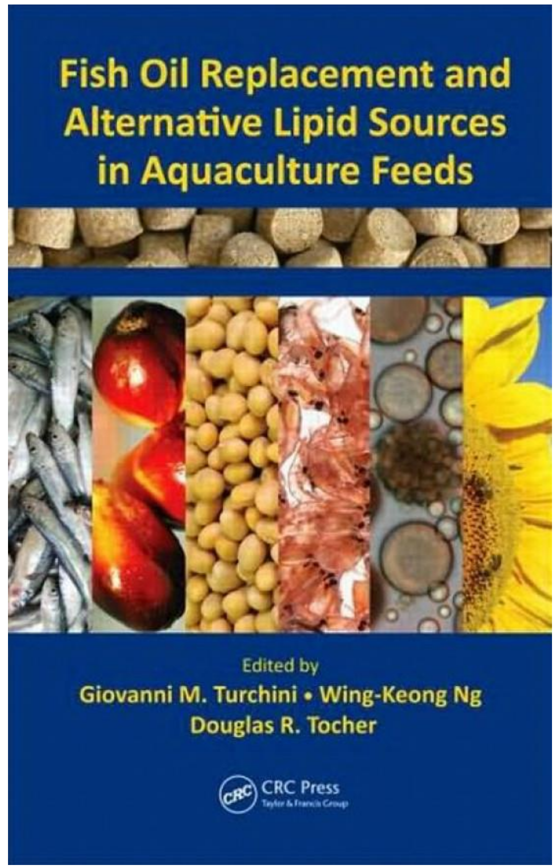
FAO, 2015

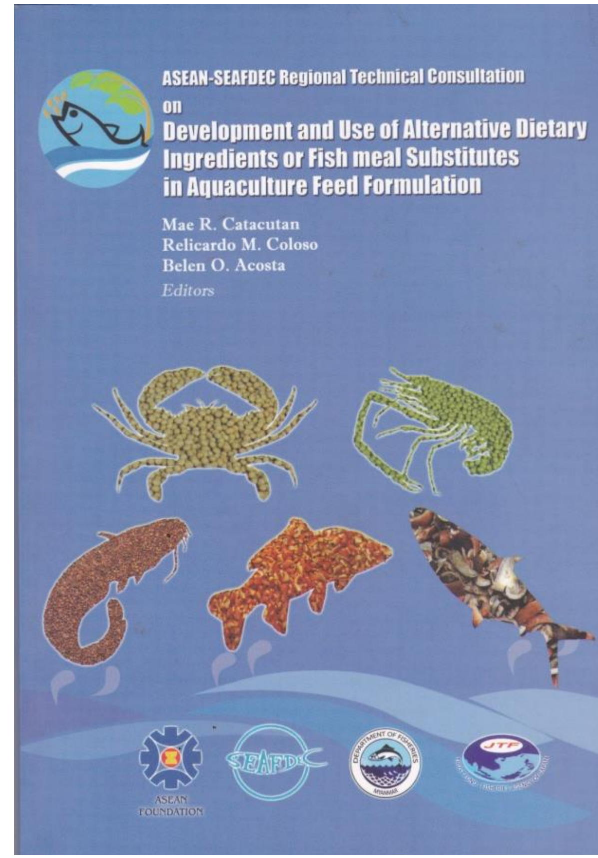
Increasing pressure from the wild for fishmeal



Aggressive research on alternative nutrient sources for fish feeds.







Knife fish meal - Tilapia

Aquaculture Reports 5 (2017) 76–83

Contents lists available at ScienceDirect

Aquaculture Reports

journal homepage: www.elsevier.com/locate/aqrep

Replacement of fishmeal with processed meal from knife fish *Chitala ornata* in diets of juvenile Nile tilapia *Oreochromis niloticus*

Sherilyn T. Abarra[a], Stephanie F. Velasquez[a], Kristina Daniela D.C. Guzman[a], Jaime Lorenzo F. Felipe[a], Melchor M. Tayamen[b], Janice A. Ragaza[a,*]

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Table 1
Proximate composition of processed meal from knife fish.

Nutrient component	(in% dry matter, DM)
Moisture	8.51 ± 0.04
Crude lipid	3.22 ± 0.14
Crude protein	62.36 ± 0.95
Crude fiber	0.18 ± 0.02
Ash	22.85 ± 0.41

Values are means of triplicate groups ± SEM.

- •75% KFM replacement of FM
- •Improved weight gain & feed intake
- •Normal hepatic histopathology

Protein enhanced copra meal - Shrimp

The Israeli Journal of Aquaculture - Bamidgeh, IJA_68.2016.1244, 6 pages

Effects of Partial Replacement of Fish Meal by Fermented Copra Meal on the Growth and Feed Efficiency in Black Tiger Shrimp, *Penaeus monodon*

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Table 1. Proximate composition of the fermented copra meal (FCM used in the formulation[1]

Parameters	*Analyzed values(%)*
Moisture	11.48
Crude protein	38.27
Crude fat	6.84
Crude fiber	6.44
Ash	9.61
Nitrogen free extract	38.83

[1] Dry matter basis.

- Replace 40% of FM
- Growth, FCR, survival & PER not affected.

Protein enhanced copra meal - Milkfish

AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Partial replacement of soybean meal with fermented copra meal in milkfish (*Chanos chanos*, Forsskal) diet

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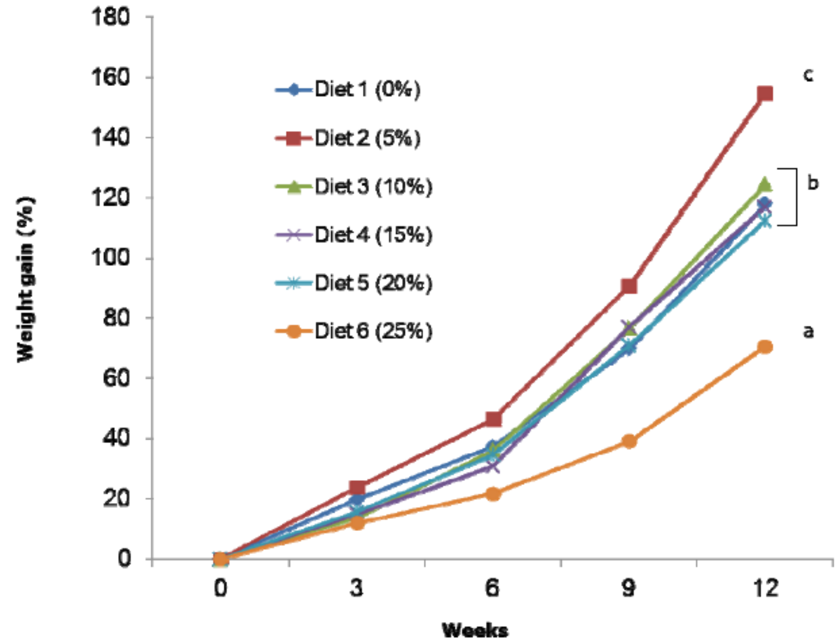

Formulation of the experimental diets (g/kg)

FCM inclusion level	0%	5%	10%	15%	20%	25%
Basal diet [a]	677.60	677.60	677.60	677.60	677.60	677.60
Soybean meal	300.00	265.00	215.00	165.00	115.00	65.00
Copra meal	15.00	0.00	0.00	0.00	0.00	0.00
Fermented copra meal [b]	0.00	50.00	100.00	150.00	200.00	250.00
L-methionine	1.20	0.80	0.55	0.24	0.09	0.00
L-threonine	1.60	1.33	1.35	1.37	1.42	1.47
L-phenylalanine	0.00	0.00	0.00	0.61	1.57	2.49
Rice bran	4.60	5.27	5.50	5.18	4.32	3.44

[a] Basal diet – Fish meal 185g, cowpea 200g, corn starch 225g, cod liver oil 30g, soybean oil 30g, vitamin mix 5g, mineral mix [illegible].5, Asc P (Tiger C) 0.1g.
[b] Purchased from a local dealer.

Various plant protein- Seabass

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Nutritional evaluation of various plant protein sources in diets for Asian sea bass *Lates calcarifer*

By P. S. Eusebio and R. M. Coloso

Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, 5021 Iloilo, Philippines

- Replacement of soybean from 13-17% in the diet

Table 3
Growth performance of juvenile Asian sea bass *Lates calcarifer* fed diets containing protein from locally available feed ingredients for 61 days and apparent protein digestibility (APD) of the diets*

Treatment	Initial weight (g)	Final weight (g)	Weight gain (%)	Specific growth rate (%/day)†	TFC	FCR	APD‡ (%)
Control (Defatted soybean)	3.8 ± 1.5	43.9 ± 5.8	1479^{a}	4.41^{a}	45.8 ± 7.1	1.12^{a}	94.0 ± 0.2^{a}
Diet 1 (White cowpea)	3.8 ± 1.5	42.1 ± 7.0	1286^{ab}	4.28^{a}	45.4 ± 8.0	1.17^{a}	91.2 ± 0.2^{b}
Diet 2 (Green mungbean)	3.7 ± 1.1	41.5 ± 4.3	1216^{ab}	4.21^{ab}	45.3 ± 5.0	1.20^{a}	91.1 ± 0.6^{b}
Diet 3 (Papaya)	3.8 ± 0.7	36.7 ± 3.0	926^{b}	3.84^{b}	45.6 ± 3.3	1.39^{b}	91.2 ± 0.4^{b}
Diet 4 (Cassava)	3.8 ± 0.6	36.7 ± 2.0	950^{b}	3.84^{b}	44.8 ± 2.6	1.37^{b}	89.2 ± 0.5^{c}
Grand mean	3.8 ± 0.05	40.2 ± 2.0	1172 ± 115	4.12 ± 0.1	45.4 6 2.2	1.25 ± 0.03	91.3 ± 0.4

Digestibility studies - Seabass

Aquaculture Research, 2004, **35**, 1261–1269 doi: 10.1111/j.1365-2109.2004.01148.x

Apparent digestibility of selected ingredients in diets for juvenile grouper, *Epinephelus coioides* (Hamilton)

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Table 4 Apparent digestibility coefficients (ADCs) for dry matter (ADC_{dm}) and crude protein (ADC_{cp}) of feed ingredients used in the formulated diets (%)*

Batch no.	Feed ingredients	ADC_{dm}	ADC_{cp}
1	Reference diet	85.4 ± 0.14	97.2 ± 0.10
	Fish meal, Chilean	83.6 ± 3.09[abc]	98.0 ± 0.07[a]
	Shrimp meal, *Acetes* sp.	76.0 ± 4.00[bc]	95.0 ± 0.72[a]
	Soybean meal, defatted	75.7 ± 1.98[bc]	96.0 ± 0.13[a]
	Fish meal, white	89.2 ± 1.69[ab]	98.6 ± 0.31[a]
	Cowpea meal, white	74.2 ± 3.14[bc]	93.5 ± 1.22[ab]
	Ipil-ipil leaf meal	56.0 ± 0.04[d]	78.8 ± 2.64[c]
2	Reference diet	84.9 ± 1.17	97.4 ± 0.81
	Squid meal	99.4 ± 0.95[a]	94.2 ± 0.21[a]
	Rice bran	68.5 ± 7.02[cd]	42.7 ± 5.38[d]
3	Reference diet	85.0 ± 1.11	93.4 ± 0.42
	Wheat flour	72.8 ± 0.85[bcd]	82.9 ± 1.26[bc]

Table 5 Growth performance of juvenile grouper *Epinephelus coioides* fed formulated diets for 80 days*

Treatment	Final weight (g)	Weight gain (%)	SGR† (% day $^{-1}$)	Feed intake (g)	FCR‡
Control (Chilean fish meal)	49.0 ± 3.8[a]	1219.5 ± 34[a]	3.2 ± 0.03[a]	64.9 ± 6.0[a]	1.4 ± 0.02[a]
Diet 1 (white fish meal)	53.0 ± 3.2[a]	1345.6 ± 55[a]	3.3 ± 0.05[a]	64.1 ± 7.1[a]	1.3 ± 0.33[a]
Diet 2 (white cowpea meal)	49.1 ± 1.9[a]	1253.7 ± 107[a]	3.2 ± 0.05[a]	61.8 ± 5.1[a]	1.4 ± 0.10[a]
Diet 3 (ipil-ipil leaf meal)	31.4 ± 3.9[b]	755.8 ± 62[b]	2.6 ± 0.10[b]	45.3 ± 5.6[a]	1.6 ± 0.05[b]

Feed pea - Milkfish

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Aquaculture 225 (2003) 89–98

Aquaculture

www.elsevier.com/locate/aqua-online

Potential of feed pea (*Pisum sativum*) meal as a protein source in practical diets for milkfish (*Chanos chanos* Forsskal)

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[b] *USA Dry Pea and Lentil Council, 2780 W. Pullman Road, Moscow, ID, USA*

Table 1
Composition (g/100 g diet) and proximate analyses of the experimental diets

Ingredients	D-1 (0%)	D-2 (5%)	D-3 (10%)	D-4 (15%)	D-5 (20%)	D-6 (25%)	D-7 (30%)	D-8 (CMF)[a]
White fish meal	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
Soybean meal	35.0	31.5	28.0	24.5	21.0	17.5	14.0	
Copra meal	13.0	13.0	13.0	13.0	13.0	13.0	13.0	
Meat and bone meal	11.0	11.0	11.0	11.0	11.0	11.0	11.0	
Vitamin mix	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Mineral mix	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Cod liver oil	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Soybean oil	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Bread flour	21.2	17.3	13.9	10.6	7.2	3.8	0.4	
Filler (Celufil)	0.8	1.7	2.0	2.3	2.6	3.0	3.3	
Green peas	–	6.5	13.1	19.6	26.2	32.7	39.3	
Proximate composition (% dry basis) of the test diets								
Crude protein	33.52	33.44	33.20	33.42	33.29	33.22	33.35	37.38
Crude fat	10.24	10.22	10.10	10.08	10.02	10.08	10.07	9.14
Crude fiber	4.66	4.96	4.42	4.39	4.94	4.51	4.63	5.20
Nitrogen-free extracts	43.54	43.34	43.96	43.37	43.33	43.79	43.70	39.18
Ash	8.04	8.04	8.32	8.74	8.42	8.40	8.25	9.10

Table 4
Response of milkfish juveniles to the various test diets after 12 weeks of feeding

Diet No.	Percentage of Survival (%)	Percentage of Weight Gain (%)	SGR (%/day)	FCR	PER
1 (0%)	90[c]	834.8[e]	1.58[e]	2.15[e]	1.44[d]
2 (5%)	90[c]	833.1[e]	1.51[e]	2.10[e]	1.46[d]
3 (10%)	90[c]	835.3[e]	1.50[e]	2.10[e]	1.44[d]
4 (15%)	80[b]	691.0[d]	1.32[d]	2.25[d]	1.37[c]
5 (20%)	80[b]	680.0[d]	1.29[d]	2.39[c]	1.35[c]
6 (25%)	70[a]	512.6[b]	0.89[b]	2.50[b]	1.21[b]
7 (30%)	70[a]	464.0[a]	0.80[a]	2.60[a]	1.15[a]
8 (CMF)	80[b]	581.4[c]	1.00[c]	2.46[b]	1.23[b]

Defatted Soybean Meal - Snapper

Aquaculture Research, 2004, **35**, 299–306

Partial replacement of fishmeal by defatted soybean meal in formulated diets for the mangrove red snapper, *Lutjanus argentimaculatus* (Forsskal 1775)

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Table 1 Composition of experimental diets*

	g 100 g $^{-1}$ diet				
	Fishmeal protein replaced by defatted soybean meal (DSM) protein (%)				
Ingredients	**0**	**12.5**	**25**	**37.5**	**50**
Peruvian fish meal†	64.00	56.00	48.00	40.00	32.00
Squid meal	3.00	3.00	3.00	3.00	3.00
DSM†	0	12.00	24.00	36.00	48.00
Dextrin	16.00	10.5	7.30	3.50	0
Common ingredients‡	16.61	16.61	16.61	16.61	16.61
Rice bran	0.39	1.89	1.09	0.89	0.39
Analysed (% dry basis)					
Crude protein	50.3	51.8	52.3	51.7	51.4
Crude fat	9.6	8.9	10.2	9.5	8.7
Crude fibre	2.2	2.3	2.3	2.1	2.2
NFE	23.4	23.7	22.1	24.3	26.7
Ash	14.6	13.4	13.1	12.4	11.0
P/E ratio (mg protein kJ $^{-1}$)	25.5	25.9	25.8	25.6	25.4

Table 2 Growth, feed efficiency, hepatosomatic index (HSI), and haematocrit of red snapper at different DSM levels for 19 weeks*

Treatments (%)	Initial avg. wt. (g) ($n = 15$)	Final avg. wt. (g) ($n = 14–15$)	SGR† (% per day) ($n = 3$)	PER‡ ($n = 3$)	FCR§ ($n = 3$)	HSI¶ ($n = 18$)	Haematocrit (%) ($n = 9$)
0	5.00 ± 0.06	90.2 ± 4.2[a]	2.18 ± 0.04[a]	0.67 ± 0.02[a]	2.8 ± 0.1[a]	2.88 ± 0.66[a]	46.6 ± 2.9[abc]
12.5	4.88 ± 0.06	90.1 ± 4.3[a]	2.19 ± 0.04[a]	0.65 ± 0.03[ab]	3.0 ± 0.1[a]	2.79 ± 0.38[a]	49.1 ± 4.4[ab]
25	4.80 ± 0.06	94.6 ± 10.0[a]	2.22 ± 0.13[a]	0.64 ± 0.02[b]	3.0 ± 0.1[a]	2.50 ± 0.63[a]	51.5 ± 3.0[a]
37.5	4.90 ± 0.10	99.8 ± 1.8[a]	2.26 ± 0.02[a]	0.66 ± 0.02[ab]	2.9 ± 0.1[a]	2.63 ± 0.83[a]	44.5 ± 2.4[bc]
50	4.80 ± 0.15	85.8 ± 6.8[a]	2.16 ± 0.04[a]	0.63 ± 0.02[b]	3.1 ± 0.1[a]	2.11 ± 0.51[a]	40.6 ± 2.5[c]

Water hyacinth - Shrimp

Aquaculture Research

Aquaculture Research, 2015, 1–8 doi: 10.1111/are.12713

Effects of water hyacinth (*Eichhornia crassipes*) leaf protein concentrate as soybean protein replacement in white shrimp *Litopenaeus vannamei* (Boone) postlarvae diet

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Table 2 Composition of experimental diets for *Litopenaeus vannamei* used to evaluate the replacement of soybean meal with WHLPC. The diets were formulated under laboratory conditions

Ingredients (g 100 g^{-1}, dry diet	Experimental diets 0%	25%	50%	75%
Defatted soybean meal	30	22	14	8
WHLPC	0	18	35	48
Fish meal	20	20	20	20
Squid meal	14	14	14	14
Fish oil/soybean oil	5	4	3.5	3
Starch	20	14	8.98	2.48
Vitamin premix†	2	2	2	2
Mineral premix‡	0.5	0.5	0.5	0.5
Lecithin	0.5	0.5	0.5	0.5
BHT	0.02	0.02	0.02	0.02
Lignobond	1.5	1.5	1.5	1.5
Alpha-cellulose	6.48	3.48	0	0
Total	100	100	100	100
Proximate Analysis (g 100 g^{-1}, dry diet)				
Crude protein	40.86	40.85	41.75	41.12
Crude fat	9.11	8.74	8.89	8.83
Crude fibre	2.84	2.67	2.99	3.57
Ash	10.20	10.66	11.13	12.27

Table 3 Growth performance and nutrient utilization of *L. vannamei*, cultured in 30-L aquarium tanks, after 70 days of culture and fed four test diets with increasing replacement levels of WHLPC

WHLPC dietary protein replacement	ABW(g)	% Weight gain	Survival (%)	SGR	FI (g/body weight)	PER	FE	Protein retention	Lipid retention
0%	1.91 ± 0.27[a]	38167.27 ± 5339.34[a]	81.67 ± 7.26	8.36 ± 0.20[a]	1.42 ± 0.09[a]	1.84 ± 0.12[a]	71.17 ± 4.65[a]	32.36 ± 1.85[a]	14.15 ± 1.37[a]
25%	1.46 ± 0.12[ab]	29104.73 ± 2362.87[ab]	88.33 ± 4.41	8.10 ± 0.11[ab]	1.25 ± 0.07[a]	2.09 ± 0.11[a]	80.78 ± 4.18[a]	26.23 ± 3.00[ab]	12.66 ± 3.63[ab]
50%	1.11 ± 0.11[bc]	22165.56 ± 2250.99[bc]	88.33 ± 7.26	7.71 ± 0.14[b]	1.49 ± 0.02[a]	1.72 ± 0.02[a]	67.38 ± 0.81[a]	19.90 ± 2.95[b]	6.96 ± 1.95[bc]
75%	0.68 ± 0.09[c]	13480 ± 1706.23[c]	100 ± 0.00	6.99 ± 0.19[c]	1.91 ± 0.02[b]	1.37 ± 0.01[b]	52.40 ± 0.40[b]	11.59 ± 1.07[c]	3.87 ± 0.82[c]

Marine annelids - Shrimp

Fish. Res. J. Philipp. Vol 10 Nos. 1-2
January-December 1985

AN EVALUATION OF THREE ANNELIDS AS FEED INGREDIENTS IN FORMULATED DIETS FOR JUVENILE *PENAEUS MONODON*

Felicidad Piedad-Pascual*

ABSTRACT

The nutrivive value of two species of earthworms, **Eisenia foetida** *and* **Eudrilus euginae** *and the marine annelid,* **Nereis** *sp. in* **P. monodon** *juvenile diets was determined in two separate experiments. Percentage weight gain and survival were higher with diets containing* **Eisenia foetida** *compared to those of diets with* **Nereis** *sp. Diets containing dried worm meal were also better compared to those with frozen worms incorporated in the "wet" form. Incorporation of earthworms at 10% level in the diets improved growth and survival when compared to a control diet. When 30% of* **Eudrilus euginae** *was used to replace fish meal in the diet, weight gain and survival of animals were higher compared to those of diets with fish meal.*

Table 5. Proximate composition of the worm meals on dry weight basis.

	Crude protein	Crude fat	Crude fiber	NFE	Crude Ash
Eisenia foetida	55.98	17.40	0.71	21.82	4.40
Nereis sp.	46.98	25.22	0.58	20.61	6.61
Eudrilus eugeniae	52.40	3.66	5.94	22.41	15.59

Leaf meals - Abalone

Aquaculture Research, 2003, **34**, 593–599

Terrestrial leaf meals or freshwater aquatic fern as potential feed ingredients for farmed abalone *Haliotis asinina* (Linnaeus 1758)

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Inclusion level of up to 45% indicates no significant difference in growth to abalone fed seaweeds.

Table 1 Proximate analyses (% DM) of *G. bailinae*, azolla and terrestrial leaf meals used as feed ingredients for *Haliotis asinina* diet

Leaf meals	Moisture	Crude protein	Crude Fat	Crude fibre	NFE	Ash
C. papaya	5.4	23.0	11.1	11.4	38.5	15.9
L. leucocephala	7.2	25.6	6.7	12.1	47.2	8.4
M. oliefera	5.6	26.6	8.2	8.8	44.4	12.4
A. pinnata	9.8	21.5	3.2	12.0	47.1	16.1
G. bailinae	7.9	12.9	0.6	4.5	33.0	48.9

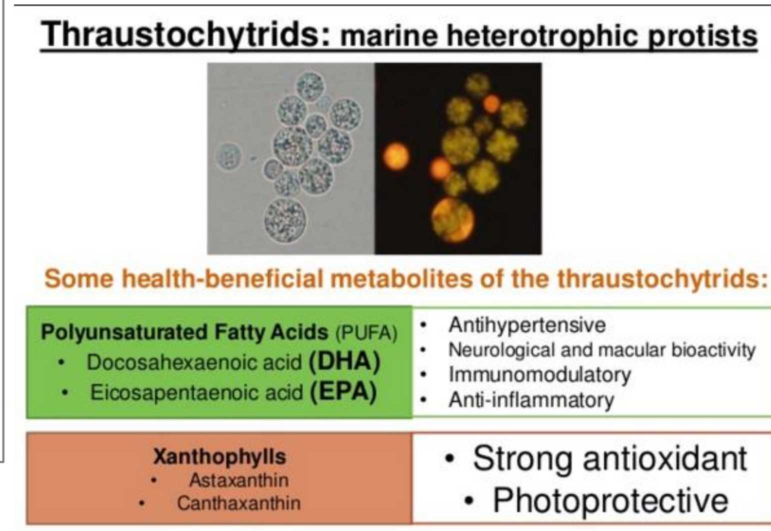
Thraustochytrid - Abalone

Aquacult Int (2016) 24:1103–1118
DOI 10.1007/s10499-016-9974-3

CrossMark

Use of thraustochytrid *Schizochytrium* sp. as source of lipid and fatty acid in a formulated diet for abalone *Haliotis asinina* (Linnaeus) juveniles

Milagros R. de la Peña[1] · Myrna B. Teruel[1] · Jose M. Oclarit[2] · Mary Jane A. Amar[3] · Ellen Grace T. Ledesma[1]



Inclusion level of up to 5.6% as a source of lipid in formulated diets for abalone.

Table 3 Proximate composition (%)[a] and lipid content of the source o

Proximate Composition (%)	Source of lipid		
	CLO	SBO	*Schizochytrium* sp.
Protein	–	–	49.55 ± 2.52
Fiber	–	–	2.85 ± 1.02
Fat	–	–	17.65 ± 0.09
Ash	–	–	10.75 ± 0.22
NFE[b]	–	–	19.20 ± 1.80
Moisture	–	–	7.46 ± 0.05
Lipid	–	–	3.89 ± 0.38

Blend of alternative ingredients - Shrimp

ELSEVIER

Aquaculture 131 (1995) 91–100

Aquaculture

Use of the golden apple snail, cassava, and maize as feeds for the tiger shrimp, *Penaeus monodon*, in ponds

I. Bombeo-Tuburan[a,*], S. Fukumoto[b], E.M. Rodriguez[a]

[a]*Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo, Philippines*

[b]*5725 Yoshino-cho, Kagoshima City, 892 Japan*

Accepted 10 October 1994

Table 3
Proximate analysis of various feeds (% dry matter basis)

	Golden snail meat	Maize	Cassava
Crude protein (%)	54.3	9.2	2.6
Crude fat (%)	1.4	0.8	0.1
Crude fiber (%)	2.0	2.4	2.7
Nitrogen-free extract (%)	20.4	86.9	92.3
Ash (%)	21.9	0.7	2.3
Calcium (%)	6.2	0.07	0.03
Phosphorus (%)	1.2	0.6	0.6

Table 2
Growth, survival, and production of *Penaeus monodon* given farm-made feeds for 4 months in ponds in Iloilo, Philippines

Feed	Carapace length (mm)	Survival (%)	Actual production (kg)	Total production (kg/ha/crop)
Maize + snails	38.5 ± 0.4^b	98.9 ± 0.6^a	13.5 ± 7.1^a	270.0 ± 0.1^a
Cassava + snails	40.3 ± 0.5^a	93.8 ± 1.8^a	13.8 ± 0.0^a	276.0 ± 0.0^a
Maize	36.4 ± 0.4^c	88.2 ± 3.3^a	9.3 ± 0.2^c	186.0 ± 4.2^c
Snails	36.7 ± 0.4^c	97.3 ± 0.5^a	11.6 ± 0.4^b	232.0 ± 7.1^b

•Combination of snail + cassava / maize as the source of protein and energy, respectively.

Hydrolysates (Tuna by-product)- Sea bream

The Israeli Journal of Aquaculture - Bamidgeh, IJA_66.2014.1021, 9 pages

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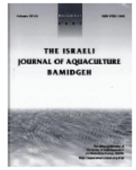

Hydrolyzed Tuna Meat By-Product Supplement for Juvenile Red Sea Bream, *Pagrus major*, and its Effect on Growth, Enzyme Activity, Plasma Parameters, and Apparent Nutrient Digestibility

Roger Edward Mamauag[1*], Janice Alano Ragaza[2], Shunsuke Koshio[3,4], Manabu Ishikawa[3], Saichiro Yokoyama[3]

[1]*Southeast Asian Fisheries Development Center, Aquaculture Department, Tigbauan, Iloilo, Philippines, 5021*

[2]*Department of Biology, School of Science and Engineering, Ateneo de Manila University, Quezon City,Philippines*

[3]*The United Graduate School of Agricultural Sciences, Kagsohima University,*

Improved :

- Digestibility
- Enzyme activity
- 25% inclusion level
- Blood plasma indcators

Table 4 Performance and whole body proximate composition (%) of red sea bream juvenile[1]

	Initial	*Control*	*TMP-H 5*	*TMP-H 15*	*TMP-H 25*	*TMP 5*	*TMP 25*
Initial body weight (g)		0.82±0.0	0.81±0.1	0.82±0.01	0.82±0.02	0.81±0.0	0.81±0.0
Final body weight (g)		22.6±0.6[a]	24.9±0.3[b]	25.3±0.4[b]	28.5±0.3[c]	22.7±0.4[a]	22±0.3[a]
Survival (%)		93.3±0.0	93.3±0.0	93.3±0.0	95.6±0.0	93.3±0.0	95.6±0.0
Feed intake[2]		21.7±0.3[a]	22±0.6[a]	22.4±0.5[a]	24.5±0.3[b]	21.9±0.3[a]	21.3±0.3[a]
FCE[3]		1.0±0.0[a]	1.1±0.0[b]	1.1±0.1[b]	1.1±0.0[b]	0.99±0.0[a]	0.99±0.0[a]
HSI[4]		1.1±0.0	1.1±0.0	1.1±0.0	1.11±0.0	1.08±0.0	1.07±0.0
Protein	9.6±0.2	11.2±0.4	11.2±0.4	11.5±0.3	112.3±0.2	111.3±0.2	111.2±0.5
Fat	1.8±0.8	2.9±0.9	2.8±0.2	2.8±0.9	2.8±0.5	2.7±0.8	2.8±0.4
Ash	2.9±0.3	3.3±0.0	3.3±0.7	3.3±0.0	3.3±0.5	3.3±0.1	3.4±0.1
Moisture	80.2±0.3	81.0±0.3	80.4±0.7	80.1±0.6	80.3±0.7	80.5±0.6	80.2±0.2

Hydrolysates (Milkfish by-product)- Grouper

Aquaculture Research
Aquaculture Research, 2016, 1–10 doi: 10.1111/are.12999

Growth and feed performance, digestibility and acute stress response of juvenile grouper (*Epinephelus fuscoguttatus*) fed diets with hydrolysate from milkfish offal

Roger Edward P Mamauag[1] & Janice A Ragaza[2]
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Ingredients	Control	MOH5	MOH15	MOH25	MO5	MO15	MO25
Performance parameters							
Initial BW	2.86 ± 0.11	2.86 ± 0.14	2.94 ± 0.2	2.85 ± 0.08	2.97 ± 0.11	2.79 ± 0.15	2.94 ± 0.15
Final BW	20.92 ± 2.08^{a}	27.11 ± 1.18^{b}	31.23 ± 1.41^{c}	30.91 ± 2.11^{c}	21.36 ± 1.87^{a}	20.90 ± 2.52^{a}	20.80 ± 1.91^{a}
%Weight gain	632.1 ± 22.4^{ab}	849.4 ± 32.47^{bc}	975.6 ± 18.47^{c}	985.1 ± 28.14^{c}	621.8 ± 25.44^{a}	650.2 ± 31.47^{ab}	606.5 ± 21.11^{a}
Survival	91.7 ± 3	97.2 ± 4	100	97.2 ± 3	97.2 ± 2	100	97.2 ± 1
FI*	17.44 ± 0.8^{a}	20.75 ± 1.1^{b}	19.89 ± 0.9^{b}	19.72 ± 1.2^{b}	17.32 ± 0.9^{a}	17.89 ± 1.0^{a}	17.78 ± 0.8^{a}
FCE†	1.05 ± 0.04^{a}	1.17 ± 0.04^{a}	1.42 ± 0.02^{b}	1.43 ± 0.07^{b}	1.07 ± 0.04^{a}	1.01 ± 0.05^{a}	1.0 ± 0.01^{a}
HSI‡	1.22 ± 0.42	1.32 ± 0.31	1.51 ± 0.25	1.47 ± 0.22	1.44 ± 0.34	1.48 ± 0.32	1.31 ± 0.18
Proximate analysis							
Protein (%DM)	60.9 ± 0.51	64.3 ± 0.43	61.5 ± 0.54	64.9 ± 0.47	63.4 ± 0.38	61.5 ± 0.41	60.5 ± 0.46

Distiller's dried grains solubles - Milkfish

Received: 16 August 2015 | Accepted: 17 May 2016
DOI: 10.1111/anu.12470

ORIGINAL ARTICLE

WILEY Aquaculture Nutrition

Nutritional evaluation of distiller's dried grain with soluble as replacement to soybean meal in diets of milkfish, *Chanos chanos* and its effect on fish performance and intestinal morphology

R.E.P. Mamauag[1] | J.A. Ragaza[2] | T.J. Nacionales[1]

[1]Aquaculture Department, Southeast Asian Fisheries Development Center, Tigbauan, Iloilo, Philippines

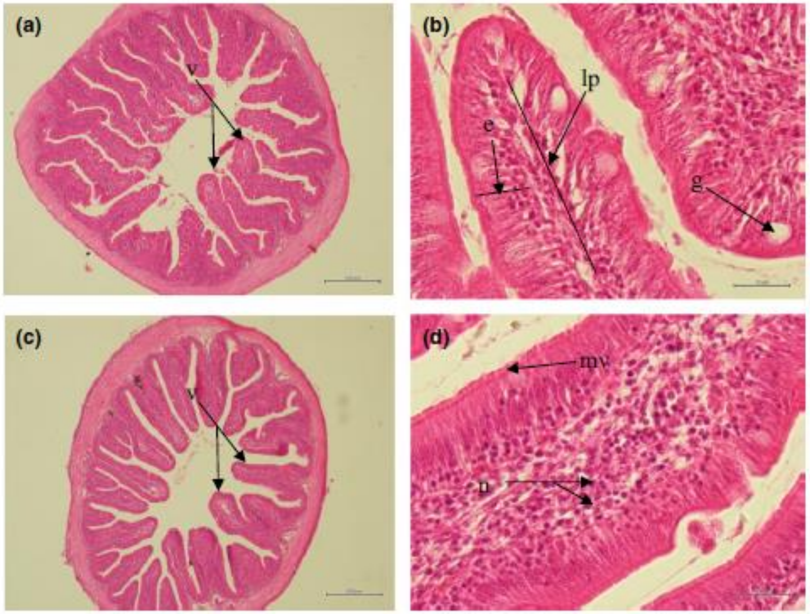
Abstract
A 90-day feeding trial was conducted on milkfish, *Chanos chanos* with an initial

Proximate analysis	
Crude protein (g/kg DM)	306.4
Crude fat (g/kg DM)	78.2
Ash (g/kg DM)	50.8
Crude fiber (g/kg DM)	62.5
NFE[j] (g/kg DM)	477.3
Energy (kcal per 100 g diet)	

TABLE 4 Performance parameters and whole body proximate composition (g/kg) of milkfish juvenile fed the experimental diets for 90 days

Ingredients	Initial	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
Performance parameters							
Initial body weight (g)		3.08 ± 0.21	3.01 ± 0.18	3.08 ± 0.25	3.10 ± 0.18	3.11 ± 0.16	3.08 ± 0.15
Final body weight (g)		21.02 ± 1.16	18.45 ± 0.38	20.11 ± 0.86	22.13 ± 1.32	18.11 ± 1.65	19.24 ± 0.55
Per cent weight gain		582.46 ± 37.8	513.16 ± 12.7	552.94 ± 28.0	613.87 ± 42.6	482.52 ± 53.2	518.76 ± 17.8
Survival (%)		82 ± 2	81 ± 1	85 ± 2	82 ± 1	85 ± 3	83 ± 1
Feed intake[a]		24.15 ± 0.8	25.08 ± 1.1	25.11 ± 1.0	24.09 ± 1.2	24.98 ± 1.1	23.98 ± 0.9
FCE[b]		0.77 ± 0.07	0.76 ± 0.04	0.77 ± 0.04	0.75 ± 0.05	0.73 ± 0.08	0.75 ± 0.05
Proximate analysis							
Crude protein (g/kg DM)	791.4 ± 2.2	731.5 ± 6.5	684.0 ± 5.8	696 ± 4.5	694 ± 7.5	690 ± 1.2	736 ± 6.3
Crude fat (g/kg DM)	49.7 ± 4.1	157.0 ± 5.0	194.0 ± 0.5	183.0 ± 6.2	164.0 ± 3.4	153.0 ± 1.1	142.0 ± 2.9

- •45% inclusion level in milkfish diets to replace soybean meal
- •N.S. effect on growth & feed efficiency
- •Normal liver & intestine histology



Use of plant-protein sources in tilapia diets for improved production traits

A-B pineapple peels; **C** sugarcane bagasse; **D** okara meal; **E-F** citrus pulp and seeds

- A great volume of agricultural wastes are generated, causing a serious disposal problem
- Options to their efficient utilization with minimal additional processing (e.g., fermentation) are needed to reduce the environmental problem

Effects of mango peel silage supplementation on growth and fry production of tilapia broodstock

- Contains 39.72-42.38% crude protein
- Heavily concentrated with carotenoids which are important for reproduction

Effects of replacing fishmeal with soybean curd residues on performance of tilapia fingerlings

Soybean curd can be fed for up to 45% inclusion level replacing fish meal

Effects of dietary supplementation of citrus peel (CPE) and citrus pulp (CPU) on performance of tilapia fingerlings

Large amount of agricultural wastes and by-products (AWB) were generated from the major agricultural crop industries

Volume of wastes produced among major agricultural crops during the 2014-2015 seasons

Crops	Production (in tons)	Type of Wastes	Amount (in tons)
Mango[1]	3,600-4,800	peels, kernel, seeds	1,800-2,400
Calamansi[1]	2,700-3,150	peel, pulp, seeds	1,755-2,047
Pineapple[1]	210	bran, peels	105-126
Sugarcane[2,3]	24,859,027	bagasse, filter cake,	9,175,010
	470,229	molasses	172,544
Papaya[1]	60	pomace, seeds	30-36
Soybean[4]	1.5	okara	1.5

[1]*Data obtained from a Fruit Processing Plant in Guiguinto, Bulacan*
[2]*SRA Annual Synopsis: Philippine Sugar Factories' Production & Performance Data 2012-2013*
[3]*Data obtained from a Sugar Central in Balayan, Batangas*
[4]*Data obtained from cottage industries in Binangonan, Rizal*

Nutritional composition of AWBs showed their potential either as protein or energy sources in tilapia diets

Agricultural wastes and by-products	% Dry matter					
	Moisture	Crude Protein	Crude Fat	Crude Fiber	NFE*	Ash
Sugarcane bagasse	6.27	2.83	0.46	33.90	55.39	7.43
Pineapple peel	6.28	4.27	0.61	9.53	81.41	4.19
Banana peel	3.19	6.44	7.41	8.02	63.33	14.81
Citrus pulp	8.09	9.28	1.30	16.00	67.32	6.11
Citrus peel	7.59	11.50	0.72	13.90	65.69	8.20
Citrus seed	1.38	15.71	31.49	8.33	39.83	4.64
Citrus, whole	2.90	11.22	2.91	10.67	69.70	5.51
Mango peel	6.25	5.93	2.15	10.95	78.06	2.93
Mango kernel	5.19	2.53	2.94	3.65	88.34	2.55
Okara	4.54	25.31	12.85	12.99	45.14	3.72

**Nitrogen Free Extract*

Pesticide residue levels in mango peels and citrus peels had exceeded the limit of quantification, but they were still lower than the MRLs set by FAO Codex Alimentarius

Agricultural wastes and by-products	Pesticide residue levels (mg/kg)*		
	Organochlorines	Pyrethroids	Organophosphates
Sugarcane baggase	<LOQ	<LOQ	<LOQ
Pineapple peels	<LOQ	<LOQ	<LOQ
Mango peels	<LOQ	0.14‡	<LOQ
Banana peels	<LOQ	<LOQ	<LOQ
Citrus peels	0.04†	<LOQ	<LOQ

*Limit of Quantification (LOQ) is 0.01 mg/kg

†Chlorpyrifos and ‡Lamba-cyhalothrin

Maximum residue limits (MRLs) for mango (0.2 mg/kg) and citrus (1 mg/kg) (FAO Codex Alimentarius)

The limitations to use agricultural wastes and by-products as feed ingredients were associated with the high levels of lignin, saponin and phenols but these ANFs can be reduced by fermentation process

Agricultural wastes and by-products	ANFs (%)				
	Tannin	Phenols	Saponin	Lignin	Alkaloid
Banana peel	0.20	0.39	-	**41.11**	0.36
Citrus seeds	0.29	0.66	0.09	**47.45**	1.10
Citrus peel	0.20	0.71	-	**31.97**	0.61
Citrus pulp	0.18	0.71	-	**24.94**	0.15
Mango kernel	0.28	**11.31**	-	**15.42**	3.90
Mango peel	0.61	ND	**3.00**	**29.00**	**16.00**
Okara meal	0.11	0.60	0.25	**41.49**	0.11
Pineapple peel	0.11	0.53	-	**21.29**	0.16
Sugarcane baggase	0.20	1.93	-	**41.49**	0.71

Alternative Ingredients Ingredients:Species: Levels

Ingredient	Species	Inclusion (%)
Gracilaria cervicornis	Pacific white shrimp	50
Fenugreek	Tilapia	2
Peanut leaves	Tilapia	20
Jatropha oil-free kernel	Tilapia	10
Jatropha oil-free kernel	Common carp	75
Jatropha oil-free kernel	Pacific white shrimp	50
Ipil Ipil , fermented	Rohu	40
Cricket meal	African catfish	10
Rubber seed meal	Tilapia	40
Fermented golden apple snails	Red tilapia	75
Minced snail meal	Red tilapia	50
Palm kernel cake	Nile tilapia	30
Golden apple snail meal	Giant Freshwater Prawn	25
Feed pea meal	Milkfish	20
Moringa oleifera	Tilapia	30
Housefly maggot meal	Barramundi	30
Poultry offal meal	*Tor tambroides*	100
Poultry by-product meal	Grouper	50

Green pea

Soybean meal

Cowpea

Lupin


Maggot


Poultry by-product


Cricket meal


Golden snail

Ingredient	**Species**	**Inclusion (%)**
Fermented copra meal	BlackTiger Shrimp	40
Water hyacinth	Common carp	40
Mung bean	Milkfish	20
Defatted Soybean Meal	*Pangasius* sp.	60
Defatted Soybean Meal	Carp	100
Cowpea meal	Milkfish	
Mung bean	Milkfish	20
Winged bean meal	African catfish	80
Moringa oleifera	Nile tilapia	30
Sunflower seed meal	Redbreast tilapia	20

Complication in amino acid profile (1)

Feedstuffs	% Protein	Limiting amino acids		
		1°	2°	3°
Maize distillers wet grains and solubles	44	Lys	Try	Arg
Maize distillers dried grains and solubles	29.5	Lys	Try	
Brewer's yeast, dehydrated	48.6	M + C	His	
Earthworm, dehydrated	61	Hys		
Feather meal	85.7	Lys	His	Trp
Blood meal	94.1	Ile	Trp	His
Poultry offal meal	60.2	Lys	Trp	His
Meat and bone meal, low fat	62	Lys	M + C	Trp
Meat and bone meal, high fat	54.9	Trp	M + C	Lys
Fish meal, 60-68% protein as fed	70.6			
Fish meal, high protein	75.4			
Maize gluten meal	67.3	Lys	Trp	Arg
Maize grain, Europe	9.4	Lys	Tre	
Wheat grain	12.6	Lys	Tre	

A. Oliva-Teles et al., 2015

Complication in amino acid profile (2)

Feedstuffs	% Protein	Limiting amino acids 1°	2°	3°
Faba bean (*Vicia faba*)	29	M + C	Trp	
Lupin (*Lupinus angustifolius*), blue seeds	33.8	M + C	Lys	Trp
Pea seeds	23.9	M + C		
Linseed meal, expeller-extracted	34.2	Lys		
Cottonseed meal, low fibre, low oil	45	Lys	M + C	Tre
Sunflower meal, solvent extracted, dehulled, partially dehulled	37.7	Lys		
Canola meal, solvent extracted	39	Lys		
Rapeseed meal, solvent extracted, low erucic, low glucosinolates	38.3	Lys		
Soybean meal, high oil (expeller)	49.3	M + C		
Soybean meal, high protein (dehulled)	53.5	M + C		

A. Oliva-Teles et al., 2015

Improvement of feeding and feed management efficiency in aquaculture production in the Philippines

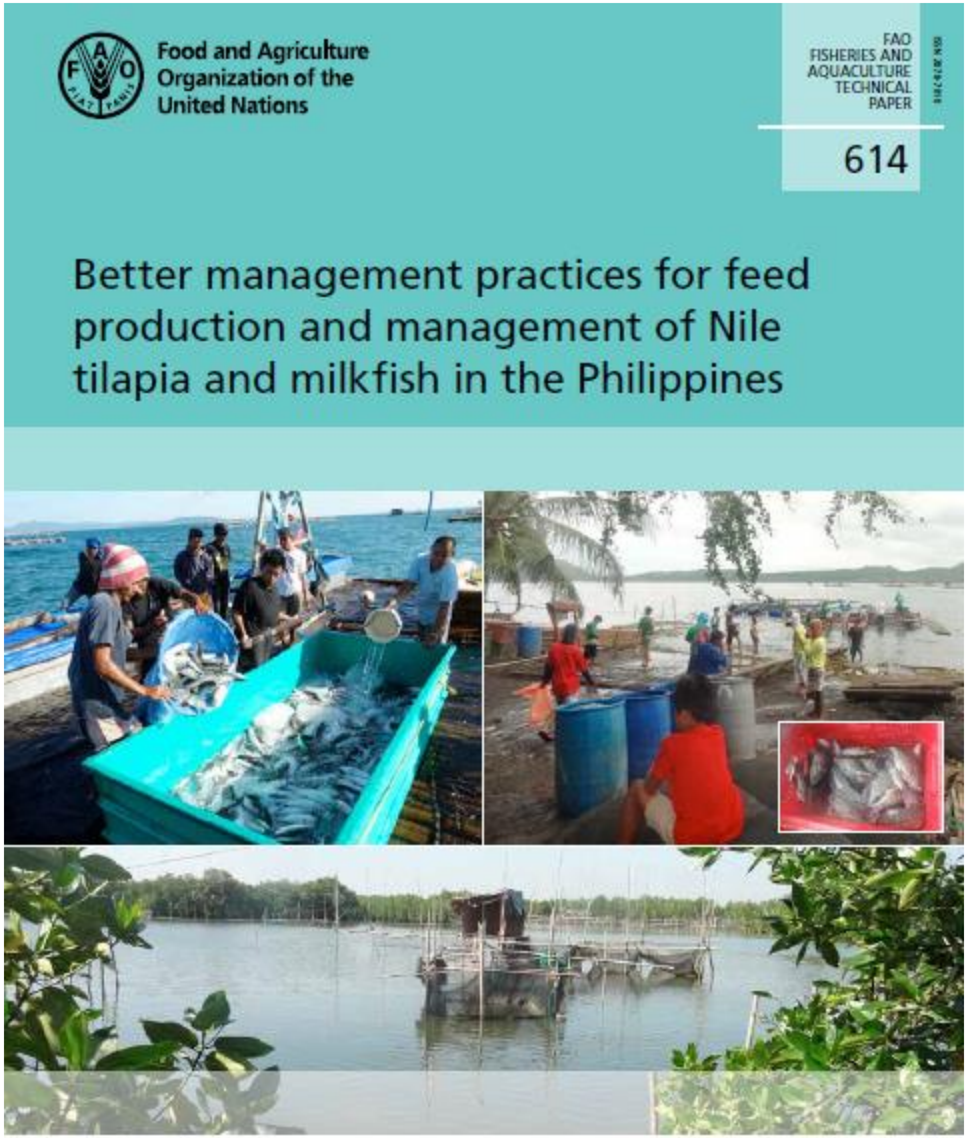
DA-BFAR & FAO-UN; 2014

Output 1: Baseline information on feed ingredient supply and availability, nutritional requirements, feed formulation for Nile tilapia and milkfish farms in the Philippines are collected.

Output 2. High quality and cost-effective feed formulations for different life stages (fry, fingerlings and on-grower) of Nile tilapia and milkfish and improved capacities for small- to medium scale feed manufac-tures to produce safe and appropriate semi-commercial and commercial aquafeeds are developed.

Output 3: Good on-farm feeding practices and feed management strategies are developed/ optimized and government extension workers and farmers are trained

Output 4: Development and promotion of national feed standards for tilapia and milkfish and appropriate institutional and regulatory frameworks for aquafeed (including feed additives and quality standards) manufacturing, quality control and distribution and policy recommendations to the government for sup-porting the sector development.


Food and Agriculture Organization of the United Nations

FAO FISHERIES AND AQUACULTURE TECHNICAL PAPER

614

Better management practices for feed production and management of Nile tilapia and milkfish in the Philippines

Overcoming the constraints

(1) Processing of alternative ingredients to improve nutrient quality

Aquaculture
Volume 459, 1 June 2016, Pages 110–116

Short communication

Effects of dietary inclusion of fermented soybean meal on growth, body composition, antioxidant enzyme activity and disease resistance of rockfish (*Sebastes schlegeli*)

Sang-Min Lee[a], Hamid Mohammadi Azarm[b], Kyung Hoon Chang[c]
Show more

http://dx.doi.org/10.1016/j.aquaculture.2016.03.036

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Aquaculture
Volume 321, Issues 3–4, 1 December 2011, Pages 252–258

Soy peptide inclusion levels influence the growth performance, proteolytic enzyme activities, blood biochemical parameters and body composition of Japanese flounder, *Paralichthys olivaceus*

R.E.P. Mamauag[a], S. Koshio[a, b], M. Ishikawa[b], S. Yokoyama[b], J. Gao[a], B.T. Nguyen[a], J.A. Ragaza[a]
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Aquaculture Nutrition
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Original Article

Evaluation of nutritive value of fermented de-oiled physic nut, *Jatropha curcas*, seed meal for Nile tilapia *Oreochromis niloticus* fingerlings

M.S. Hassaan, A.M.A.-S. Goda, V. Kumar

First published: 5 April 2016 Full publication history
DOI: 10.1111/anu.12424 View/save citation

Early View

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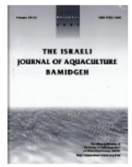
Animal Feed Science and Technology
Volume 220, October 2016, Pages 168–179

The effects of fish hydrolysate and soy protein isolate on the growth performance, body composition and digestibility of juvenile pike silverside, *Chirostoma estor*

G.H. Ospina-Salazar[a], M.G. Ríos-Durán[b], E.M. Toledo-Cuevas[b], C.A. Martínez-Palacios[b]
Show more

(2) Recovery and utilization of fisheries processing waste should be encouraged and increased.

The Israeli Journal of Aquaculture - Bamidgeh, IJA_66.2014.1021, 9 pages



Hydrolyzed Tuna Meat By-Product Supplement for Juvenile Red Sea Bream, *Pagrus major*, and its Effect on Growth, Enzyme Activity, Plasma Parameters, and Apparent Nutrient Digestibility

Roger Edward Mamauag[1*], Janice Alano Ragaza[2], Shunsuke Koshio[3,4], Manabu Ishikawa[3], Saichiro Yokoyama[3]

[1] *Southeast Asian Fisheries Development Center, Aquaculture Department, Tigbauan, Iloilo, Philippines, 5021*

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Aquaculture Research

Aquaculture Research, 2016, 1–10 doi: 10.1111/are.12999

Growth and feed performance, digestibility and acute stress response of juvenile grouper (*Epinephelus fuscoguttatus*) fed diets with hydrolysate from milkfish offal

Roger Edward P Mamauag[1] & Janice A Ragaza[2]
[1] Southeast Asian Fisheries Development Center, Aquaculture Department, Iloilo, Philippines
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Correspondence: R E P Mamauag, Southeast Asian Fisheries Development Center, Aquaculture Department, Tigbauan, Iloilo 5021, Philippines. E-mail: ermamauag@seafdec.org.ph

(3) Scientific information on nutritional requirements of farmed fish species, and feed ingredients and the interaction between fish and diet.

Fisheries Science
January 2011, Volume 77, Issue 1, pp 119–128

Growth, nutrient utilization, oxidative condition, and element composition of juvenile red sea bream *Pagrus major* fed with fermented soybean meal and scallop by-product blend as fishmeal replacement

Authors | Authors and affiliations

Md. Abdul Kader, Shunsuke Koshio, Manabu Ishikawa, Saichiro Yokoyama, Mahbuba Bulbul, Yuki Honda, Roger Edward Mamauag, Asda Laining

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ORIGINAL ARTICLE

WILEY Aquaculture Nutrition

Nutritional evaluation of distiller's dried grain with soluble as replacement to soybean meal in diets of milkfish, *Chanos chanos* and its effect on fish performance and intestinal morphology

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Abstract
A 90-day feeding trial was conducted on milkfish, *Chanos chanos* with an initial

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Redefining the requirement for total sulfur amino acids in the diet of barramundi (*Lates calcarifer*) including assessment of the cystine replacement value

David A. Poppi[a, b], Stephen S. Moore[a], Brett D. Glencross[c]
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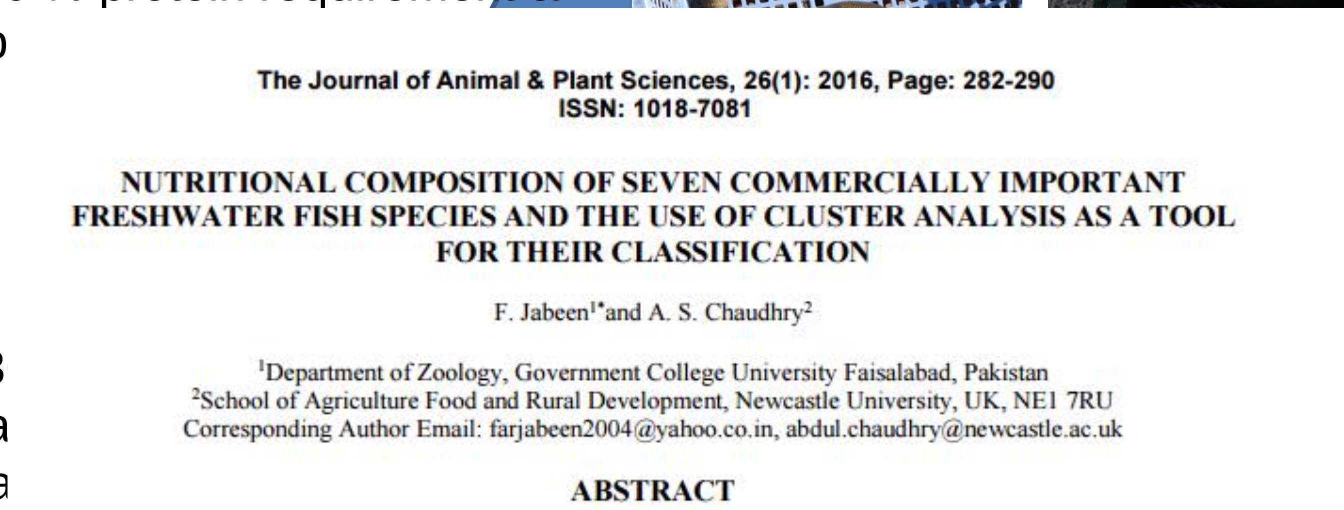
(4) Promoting herbivorous species for aquaculture

A 40- 60 % protein requirement &
12% lip



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NUTRITIONAL COMPOSITION OF SEVEN COMMERCIALLY IMPORTANT FRESHWATER FISH SPECIES AND THE USE OF CLUSTER ANALYSIS AS A TOOL FOR THEIR CLASSIFICATION

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ABSTRACT

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- Reduce use of fish meal & fish oil
- Efficient conversion of nutrient inputs
- Environmentally sensible
- Sustainable