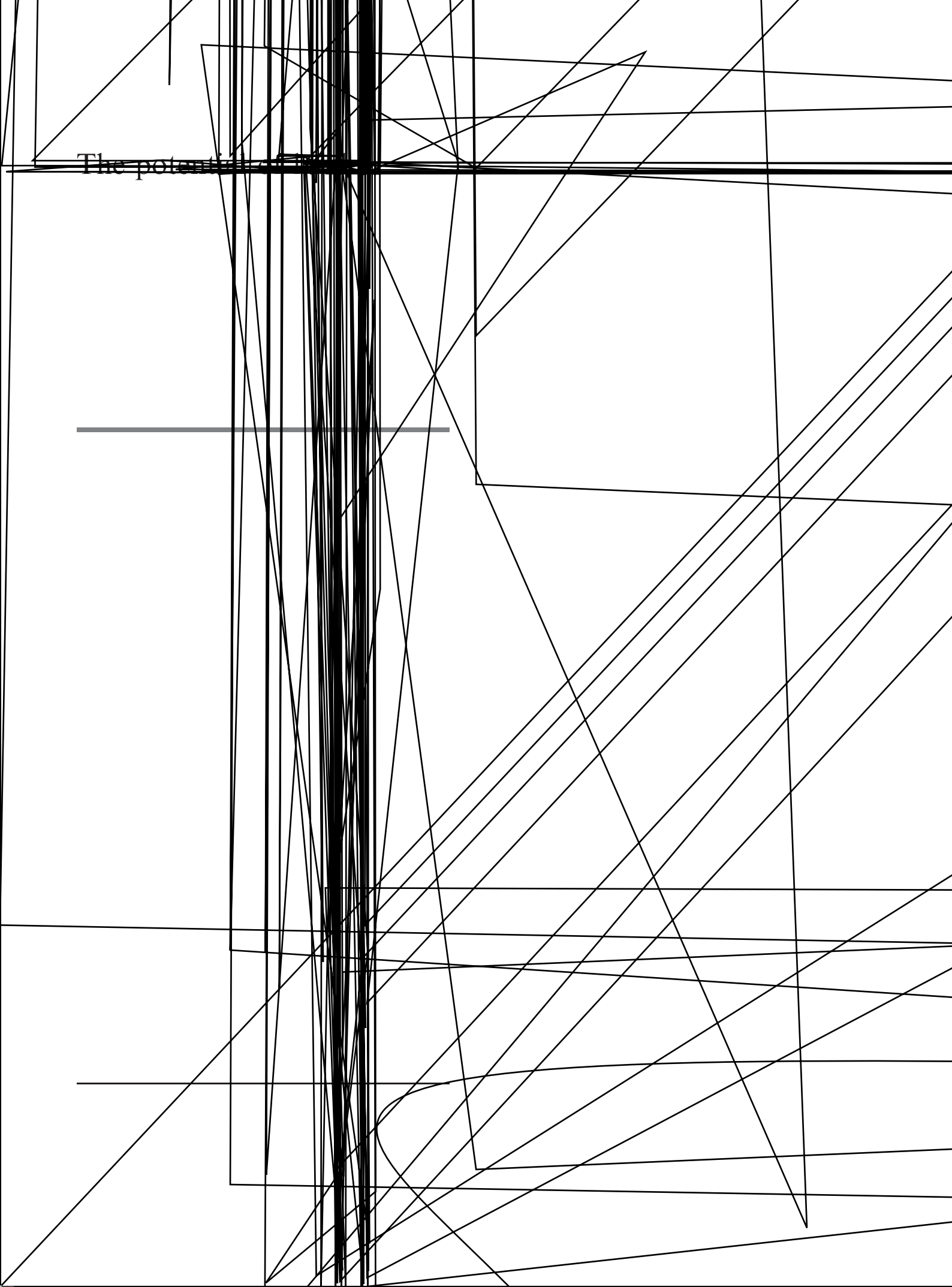

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Materials and methods

Ingredients, diet formula

Table 1

	LR3	LR4
	80	
	282	352
	11	15
	200	200
	50	50
	257	263
	15	15
	5	5
	75	80
	10	10
	10	10
	902	902
	412	360
	136	145
	92	86
	18.5	18.7
	347	347
	15.1	15.2
	23.0	22.9

Diet HC, HR1, HR2, HR3 and HR4 contained 400 g kg^{-1} digestible protein, and diet LC, LR1, LR2, LR3 and LR4 contained 350 g kg^{-1} digestible protein. At each of the protein levels, a basal diet (HC or LC) contained 400 g kg^{-1} herring meal, and 30% (HR1 or LR1), 50% (HR2 or LR2), 80% (HR3 or LR3) and 100% (HR4 or LR4) of the fish meal in the basal diet was replaced with a protein blend.

Vitamin premix and mineral premix are described as Wang *et al.* (2006a). Crude protein, crude lipid, ash and gross energy are expressed on a dry matter basis and given as means (n = 2).

[1] Protein blend comprises of 600 g kg^{-1} poultry by product meal, 200 g kg^{-1} meat and bone meal, 100 g kg^{-1} feather meal and 100 g kg^{-1} blood meal.

[2] DP, digestible protein; DE, digestible energy. DP and DE are calculated using the method described as Wang *et al.* (2006a), and expressed on a dry matter basis.

Table 2

Feeds	Thr	Val	Cys	Met	Ile	Leu	Tyr	Phe	Lys	His	Arg
HC	17.1 (36.2)	19.6 (41.5)	2.0 (4.2)	11.1 (23.5)	14.6 (30.9)	34.9 (73.9)	11.6 (24.6)	19.8 (41.9)	28.7 (60.8)	16.3 (34.5)	26.2 (55.5)
HR1	17.7 (37.2)	19.9 (41.8)	2.0 (4.2)	11.5 (24.2)	15.5 (32.6)	36.3 (76.3)	12.1 (25.4)	21.0 (44.1)	30.8 (64.7)	17.2 (36.1)	26.7 (56.1)
HR2	17.1 (34.9)	20.1 (41.0)	3.4 (6.9)	9.5 (19.4)	14.5 (29.6)	36.0 (73.5)	11.3 (23.1)	20.5 (41.8)	28.4 (58.0)	17.7 (36.1)	26.8 (54.7)
HR3	16.5 (35.2)	20.0 (42.6)	4.2 (9.0)	9.0 (19.2)	14.1 (30.1)	35.5 (75.7)	10.3 (22.0)	19.9 (42.4)	26.5 (56.5)	17.1 (36.5)	27.5 (58.6)
HR4	16.5 (34.8)	19.7 (41.6)	3.3 (7.0)	9.1 (19.2)	13.7 (28.9)	35.1 (74.1)	10.1 (21.3)	19.9 (42.0)	25.7 (54.2)	17.5 (36.9)	27.6 (58.2)
LC	15.0 (36.1)	15.5 (37.3)	2.7 (6.5)	12.2 (29.3)	14.0 (33.7)	27.9 (67.1)	10.6 (25.5)	16.9 (40.6)	24.7 (59.4)	12.8 (30.8)	22.9 (55.0)
LR1	14.8 (35.4)	15.5 (37.1)	2.3 (5.5)	11.6 (27.8)	14.0 (33.5)	28.0 (67.0)	10.0 (23.9)	16.0 (38.3)	23.5 (56.2)	13.5 (32.3)	22.6 (54.1)
LR2	14.5 (37.1)	15.5 (39.6)	2.5 (6.4)	6.6 (16.9)	13.1 (33.5)	27.5 (70.3)	9.5 (24.3)	16.5 (42.2)	22.4 (57.3)	13.3 (34.0)	22.9 (58.6)
LR3	14.2 (34.5)	15.9 (38.6)	3.7 (9.0)	13.4 (32.5)	12.6 (30.6)	27.6 (67.0)	9.3 (22.6)	15.9 (38.6)	20.9 (50.7)	13.6 (33.0)	23.3 (56.6)
LR4	13.4 (37.2)	13.7 (38.1)	1.7 (4.7)	9.6 (26.7)	12.2 (33.9)	24.3 (67.5)	9.0 (25.0)	14.5 (40.3)	16.1 (44.7)	11.5 (31.9)	22.1 (61.4)

Diet HC, HR1, HR2, HR3 and HR4 contained 400 g kg^{-1} digestible protein, and diet LC, LR1, LR2, LR3 and LR4 contained 350 g kg^{-1} digestible protein. At each of the protein levels, a basal diet (HC or LC) contained 400 g kg^{-1} herring meal, and 30% (HR1 or LR1), 50% (HR2 or LR2), 80% (HR3 or LR3) and 100% (HR4 or LR4) of the fish meal in the basal diet was replaced with a protein blend.
Data are expressed on a dry weight basis (g kg^{-1}) as % of diet or (% of protein).

Data calculation and statistics

(, %) (2006).

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$P < 0.05$.

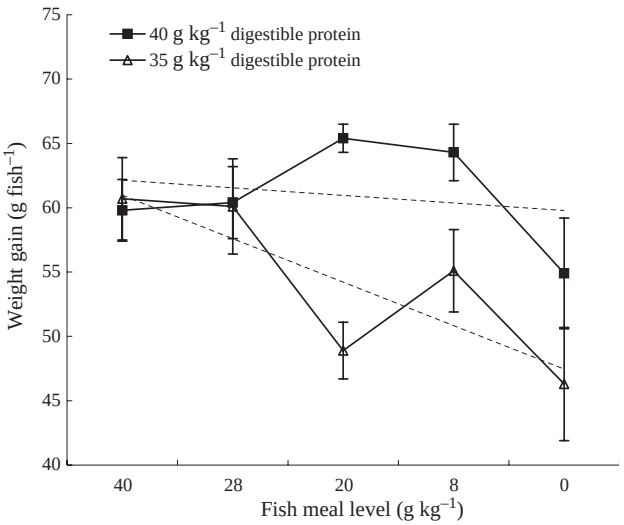

Figure 1

Results

(>99%)
($P > 0.05$, 3). ,
($P < 0.05$).
350 $^{-1}$ (15, ^{2} 0.367,
$P < 0.05$, . 1),
400 $^{-1}$
(15, ^{2} 0.019, $P > 0.05$).
,

(400 350 $^{-1}$, $P > 0.05$, 3).
0 $^{-1}$ 350 $^{-1}$
($P < 0.05$),
400 $^{-1}$ ($P > 0.05$).
400 $^{-1}$ 0 $^{-1}$
350 $^{-1}$

Table 3 ($^{-1}$), ($^{-1}$), , (%)

Feeds	Initial body weight	Final body weight	Feed intake	Feed conversion ratio	Nitrogen retention efficiency	Ratio of fish meal consumption to fish production
HC	41.6 ± 0.5	101.4 ± 2.5^{ab}	66.1 ± 3.6	1.12 ± 0.03^{a}	34.8 ± 0.8^{ab}	1.62 ± 0.03^{a}
HR1	43.5 ± 0.8	103.9 ± 3.3^{ab}	66.2 ± 3.0	[1]1.10 ± 0.00^{a}	35.0 ± 0.3^{ab}	1.16 ± 0.02^{b}
HR2	42.2 ± 1.1	107.6 ± 2.1^{ab}	68.8 ± 2.3	1.06 ± 0.03^{a}	35.4 ± 1.3^{ab}	0.78 ± 0.04^{c}
HR3	42.1 ± 0.8	106.3 ± 2.8^{a}	69.2 ± 1.0	1.12 ± 0.02^{a}	36.3 ± 0.2^{ab}	0.32 ± 0.00^{d,1}
HR4	40.8 ± 0.2	95.8 ± 4.1^{ab}	65.2 ± 2.3	1.21 ± 0.06^{ab}	31.4 ± 1.5^{b}	0^{e}
LC	41.9 ± 0.9	102.6 ± 2.9^{ab}	71.5 ± 4.2	1.21 ± 0.03^{ab}	35.5 ± 0.9^{ab}	1.70 ± 0.07^{a}
LR1	41.8 ± 1.1	101.9 ± 3.9^{ab}	66.5 ± 3.4	1.14 ± 0.02^{ab}	37.1 ± 0.6^{a}	1.17 ± 0.03^{b}
LR2	42.7 ± 1.3	91.6 ± 2.3^{b}	65.6 ± 1.2	1.35 ± 0.04^{bc}	33.8 ± 1.0^{ab}	0.92 ± 0.01^{c}
LR3	42.9 ± 1.0	98.1 ± 2.5^{ab}	67.1 ± 1.3	1.22 ± 0.05^{ab}	34.5 ± 0.9^{ab}	0.36 ± 0.00^{d,1}
LR4	42.2 ± 1.2	88.5 ± 3.9^{b}	66.0 ± 2.7	1.46 ± 0.08^{c}	33.1 ± 1.7^{ab}	0^{e}

Diet HC, HR1, HR2, HR3 and HR4 contained 400 g kg^{-1} digestible protein, and diet LC, LR1, LR2, LR3 and LR4 contained 350 g kg^{-1} digestible protein. At each of the protein levels, a basal diet (HC or LC) contained 400 g kg^{-1} herring meal, and 30% (HR1 or LR1), 50% (HR2 or LR2), 80% (HR3 or LR3) and 100% (HR4 or LR4) of the fish meal in the basal diet was replaced with a protein blend.

Letters indicate results of Turkey HSD test. The values in same column with different superscripts are significantly different at 0.05 level.

Feed intake and feed conversion ratio are expressed on a dry diet basis.

[1] SEM < 0.005.

The values are represented as mean ± SEM, $n = 3$.

Table 4 ($^{-1}$)

Feeds	Moisture	Crude protein	Crude lipid	Ash
Initial	751 ± 2	180 ± 2	22 ± 2	49 ± 1
HC	735 ± 3	182 ± 1^{ab}	44 ± 1^{ab}	42 ± 0^{ab,1}
HR1	742 ± 2	182 ± 1^{ab}	38 ± 3^{a}	42 ± 1^{ab}
HR2	738 ± 4	183 ± 2^{ab}	41 ± 5^{ab}	41 ± 1^{a}
HR3	732 ± 2	186 ± 2^{b}	44 ± 0^{ab,1}	42 ± 1^{ab}
HR4	739 ± 2	180 ± 1^{ab}	40 ± 2^{ab}	44 ± 1^{b}
LC	730 ± 5	179 ± 2^{ab}	49 ± 4^{ab}	43 ± 0^{ab,1}
LR1	737 ± 3	178 ± 1^{a}	44 ± 2^{ab}	43 ± 1^{ab}
LR2	728 ± 3	179 ± 0^{ab,1}	54 ± 5^{b}	44 ± 1^{b}
LR3	737 ± 4	176 ± 3^{a}	47 ± 2^{ab}	43 ± 1^{ab}
LR4	733 ± 3	176 ± 1^{a}	47 ± 3^{ab}	44 ± 0^{b,1}

Diet HC, HR1, HR2, HR3 and HR4 contained 400 g kg^{-1} digestible protein, and diet LC, LR1, LR2, LR3 and LR4 contained 350 g kg^{-1} digestible protein. At each of the protein levels, a basal diet (HC or LC) contained 400 g kg^{-1} herring meal, and 30% (HR1 or LR1), 50% (HR2 or LR2), 80% (HR3 or LR3) and 100% (HR4 or LR4) of the fish meal in the basal diet was replaced with a protein blend.

Letters indicate results of Turkey HSD test. The values in same column with different superscripts are significantly different at 0.05 level.

Crude protein, crude lipid and ash are expressed on a wet weight basis.

[1] SEM < 0.5.

The values are represented as mean ± SEM, n = 3.

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($P < 0.05$),

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($P > 0.05$, 4).

Discussion

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(360, 380 400 $^{-1}$

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(280 $^{-1}$)

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($^{-1}$)

22.1, 27.9, 2.1,

17.7, 24.6, 42.8, 15.4, 22.5, 45.6, 12.3

39.5 (. 2006).

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