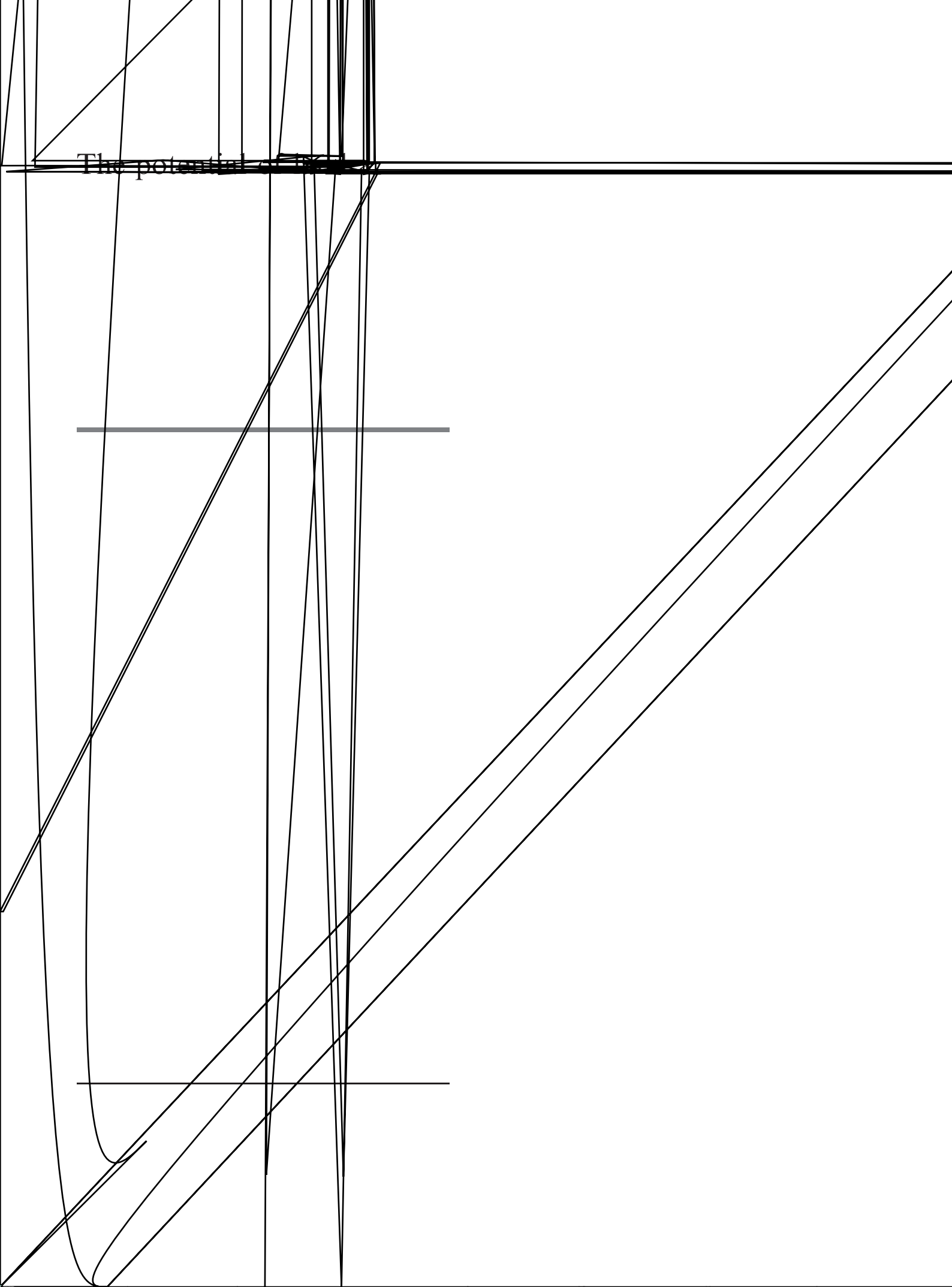

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Materials and metho

Ingredients list f

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

Ingredient	Diets									
	HC	HR1	HR2	HR3	HR4	LC	LR1	LR2	LR3	LR4
Fish meal	400	280	200	80		400	280	200	80	
Protein blend[1]		105	177	282	352		105	177	282	352
Blood meal	74	61	76	72	65	10	8	6	11	15
Soybean meal	200	230	200	216	243	180	200	200	200	200
Rapeseed meal	50	50	50	50	50	50	50	50	50	50
Wheat flour	186	180	212	210	200	240	248	252	257	263
$CaHPO_4$	15	15	15	15	15	15	15	15	15	15
DL-Met	5	5	5	5	5	5	5	5	5	5
Fish oil	50	50	45	50	50	80	69	75	80	80
Vitamin premix	10	10	10	10	10	10	10	10	10	10
Mineral premix	10	10	10	10	10	10	10	10	10	10
Dry matter	911	903	905	903	903	909	905	902	906	902
Crude protein	472	476	490	469	474	416	418	391	412	360
Crude lipid	86	82	91	97	95	140	130	136	136	145
Ash	113	106	100	93	88	113	107	102	92	86
Gross energy	17.2	17.5	17.7	18.2	18.4	17.5	17.6	18.0	18.5	18.7
DP[2]	396	395	395	393	393	347	349	347	347	347
DE[2]	14.4	14.4	14.5	14.7	14.7	14.7	14.5	14.8	15.1	15.2
DP/DE (g MJ^{-1})	27.6	27.4	27.3	26.8	26.7	23.6	24.0	23.5	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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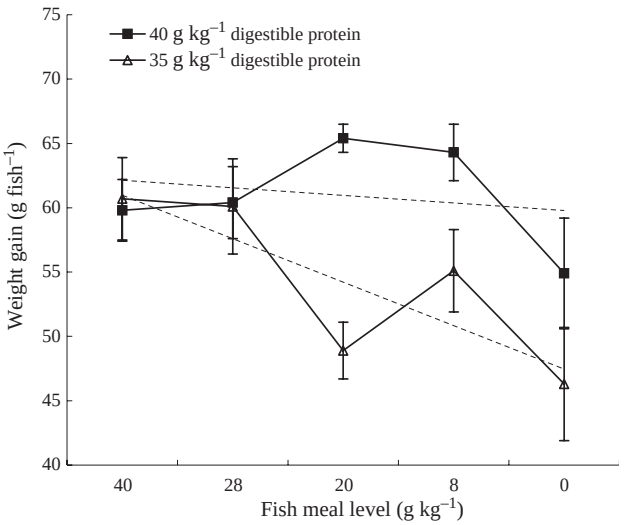

Figure 1

Results

(>99%)
($P > 0.05$, 3). ,
($P < 0.05$).
350 $^{-1}$ (15, ^{2} 0.367,
$P < 0$. 1),
400 $^{-1}$
(5, ^{2} 0.019, $P > 0.05$). -
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(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	ial body ght	Final body weight	Feed intake	Feed conversion ratio	Nitrogen retention efficiency	Ratio of fish meal consumption to fish production
HC	± 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	± 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	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	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	0.2	95.8 ± 4.1^{ab}	65.2 ± 2.3	1.21 ± 0.06^{ab}	31.4 ± 1.5^{b}	0^{e}
LC	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	.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	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	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	2	88.5 ± 3.9^{b}	66.0 ± 2.7	1.46 ± 0.08^{c}	33.1 ± 1.7^{ab}	0^{e}

Diet H nd HR4 contained 400 g kg^{-1} digestible protein, and diet LC, LR1, LR2, LR3 and LR4 contained 350 g kg^{-1} digestible 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% (H 0% (HR4 or LR4) of the fish meal in the basal diet was replaced with a protein blend.
Letters Turkey HSD test. The values in same column with different superscripts are significantly different at 0.05 level.
Feed i ersion ratio are expressed on a dry diet basis.
[1] SEM
The va 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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Discussion

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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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