Short Paper

Simple Methods for Estimation of Metabolizable Energy and Net Energy for Production in Diets for Fingerling Carp^{*1}

Suitability of digestible energy (DE), metabolizable energy (ME) and net energy for production (NEp) to predict utilization and effects of diets in fish production was tested against the data from 6-week feeding trial which were previously reported in detail.¹⁾ Also attempts were made to establish simple methods for estimation of ME and NEp using DE value and EAA index (based on A/E ratios instead of percentages of essential amino acids of hen's whole egg as the reference value) of each experimental diet.

Six purified diets having different amino acid balances (79-90 in EAA index) were fed to duplicate groups of fingerling carp with initial mean weight of 2.1 g at 25°C for 6 weeks. Proximate analyses of the pooled whole carcasses (5-10 fish/tank) were carried out at the end of the feeding trial. Gross energy (GE) values of the diets were determined by a bomb calorimeter and DE of each diet was calculated as described previously.¹⁾ ME values were computed based on the difference between nitrogen absorbed and deposited, because ammonia is the principal end product of protein catabolism in fishes²⁾ and nitrogen which was not incorporated into the body can be considered to be excreted as ammonia. The computation was made as follows; MEN (kcal/g diet) = DE - (N absorbed - N deposited) × 5.94 kcal/g N³⁾ ÷ diet fed (g). On the diets with odd numbers (Table 1), metabolizable energy (MEc) was also determined on carp with body weights of 500-600 g by the conventional method using urinary energy measured at 20°C according to OGINO *et al.*⁴⁾ NEp was determined by the comparative slaughter method⁵⁾ and calculated using the following equation; NEp = (protein gain × 5.65 kcal/g + fat gain × 9.40 kcal/g) ÷ diet fed (g), where 5.65 and 9.40 are heat of combustion for protein and fat, respectively. Highly significant ($P < 0.001$) linear relationships were detected between either MEN or NEp, and the product of DE and EAA index of the respective diet. Thus, ME and NEp of

each diet were estimated using the following regression equations: ME_{es} (kcal/g diet) = $2.16 + 0.44$ (DE × EAA index); NEp_{es} (kcal/g diet) = $-3.07 + 1.26$ (DE × EAA index). These energy values were summarized in Table 1.

The correlation coefficients between these energy values and the performances of the fish (Table 2) indicated that NEp is the best value for prediction of fish production and MEN is inferior to NEe, but much better than DE. The poor correlation coefficients for MEc may be due to the differences in water temperature and size of the fish used for the feeding trial¹⁾ and the measurement of the urinary energy or insufficient number for MEc value. Judging from the highly significant ($P < 0.01$ or 0.001) correlation coefficients between either of ME_{es} or NEp_{es} and the performances of the fish in all categories listed in Table 2, both of these estimated values can be used for prediction of fish production as accurate as those based on a long feeding trial. Applicability of this method for a practical type diet will be tested in the next study.

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Table 1. Various energy values (kcal/g) of the experimental diets having different amino acid balance

Diet No.	Treatment ¹⁾	GE	DE	MEN*	MEc**	NEp*	ME, es	NEp, es
1	C35-G00	4.90	3.92	3.72 ± 0.007	3.81 ± 0.015	1.14 ± 0.014	3.69	1.31
2	C30-G05	4.85	3.88	3.69 ± 0		1.31 ± 0.092	3.70	1.33
3	C25-G10	4.81	3.84	3.65 ± 0.007	3.70 ± 0.009	1.29 ± 0	3.68	1.29
4	C20-G15	4.75	3.79	3.58 ± 0.007		1.27 ± 0.028	3.63	1.13
5	C15-G20	4.70	3.74	3.50 ± 0	3.61 ± 0.008	0.98 ± 0.042	3.55	0.92
6	C10-G25	4.67	3.71	3.43 ± 0		0.64 ± 0.007	3.47	0.67
7	C05-G30	4.63	3.68	3.36 ± 0.007	3.49 ± 0.029	0.27 ± 0.049	3.34	0.32

* Mean value of duplicate tanks ± SD.

** Mean value of three trials ± SD.

Table 2. Correlation coefficients (df=5, except MEc whose df=2) between various energy values and performances of the fish

Performance ¹⁾	DE	MEN	MEc	NEp	ME, es	NEp, es
% wt gain (4-6)	0.798*	0.880**	0.869	0.970***	0.949**	0.949**
% wt gain (0-6)	0.792*	0.878**	0.832	0.983***	0.945**	0.946**
Feed efficiency (4-6)	0.825*	0.907**	0.867	0.993***	0.971***	0.971***
Feed efficiency (0-6)	0.830*	0.913**	0.882	0.997***	0.977***	0.977***
% N deposited (0-6)	0.860*	0.933**	0.904*	0.994***	0.986***	0.986***
% energy deposited (0-6)	0.771*	0.866**	0.852	0.998***	0.955***	0.954***

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

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