Bioenergetics

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10-Urinary and Branchial Energy and Metabolizable Energy 1
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Factors Affecting Metabolic Waste Output

1- Dietary Factors

The main factors affecting non-fecal energy losses are those that influence the retention of protein by the body and hence govern the loss of nitrogenous end products through the gills or in the urine. One such factor is the balance between digestible protein (available amino acid) energy and non-protein energy of the diet. This balance is represented by the ratio of digestible protein (DP) to DE of the diet (DP/DE). Numerous studies have shown that an increase in dietary DE by an increase in dietary non-protein energy led to a decrease in ammonia nitrogen excretion, UE+ZE, and hence to an increase in ME .

$$\boxed{\mathrm{ME} = \mathrm{DE} - (\mathrm{ZE} + \mathrm{UE})}$$

Studies with rainbow trout have shown that the regression slopes between nitrogen intake and nitrogen excretion as well as the basal nitrogen excretion levels are affected by the DP/DE of the diet.

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It can therefore be concluded that, in general, UE+ZE decreases as DP/DE decreases, at least within a certain range of DP/DE.

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This decrease in non-fecal N excretion and UE+ZE is due to the utilization of non-protein energy sources for meeting energy requirements, resulting
in a reduction in catabolism of a certain proportion of amino acid for energy purposes. This phenomenon is referred to as "protein-(amino acid) sparing."
Protein-sparing by lipids has been shown to occur in a majority of fish species. Protein-sparing by digestible carbohydrates such as glucose and gelatinized starch is more limited and the object of continuing studies.
The amino acid composition of the diet is another factor that has a determinant effect on the efficiency of nitrogen utilization and UE+ZE.

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Feeding amino acids in excess of the requirement will result in catabolism of the amino acid, with associated excretion of ammonia and loss of energy. The total digestible nitrogen retention efficiency rarely exceeds 50% in rainbow trout (60% in Atlantic salmon) fed diets with very low DP :DE ratios (16g DP/MJ DE) with a good amino acid balance. It is not clear to what extent this significant catabolism of amino acids, despite a sufficient supply of non-protein energy, is related to 1- maintenance requirements, 2- imbalances, or 3- unavoidable catabolism of amino acids.

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The excretion of glucose in the urine means that diets containing high levels of digestible carbohydrate may have a ME content lower than that calculated only on the basis of nitrogenous waste energy excretion.

2- Other Factors

Feeding level and water temperature do not appear to have any effect on the ME/DE ratio of diets .
Interspecific differences in nitrogen excretion and consequently ME are little studied.
Significant differences observed in efficiency of N retention in seabass and rainbow trout fed similar diets.

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Marine fish species appear to retain a much lower proportion of the digestible protein fed to them than do salmonid fish species and therefore have significantly higher UE+ZE values .

Differences in N retention efficiency are also evident between salmonid fish species. Atlantic salmon appear to retain a greater proportion of the digestible protein than do rainbow trout when these two species are fed similar diets . Available data do not appear to indicate any significant influence of genetic origin (strain, family, ploidy) on nitrogen excretion per unit N intake

Factors Affecting Metabolic Waste Output

Estimation of Excretory And Feed Waste Outputs:

Waste output loading from aquaculture operations can be estimated using simple principles of nutrition and bioenergetics. Ingested feedstuffs must be digested prior to utilization by the fish and the digested protein, lipid and carbohydrate are the potentially available energy and nutrients for maintenance, growth and reproduction of the animal. The remainder of the feed (undigested) is excreted in the feces as solid waste (SW), and the by-products of metabolism (ammonia, urea, phosphate, carbon dioxide, etc.) are excreted as dissolved waste (DW) mostly by the gills and kidneys.

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The total aquaculture wastes (TW) associated with feeding and production is made up of SW and DW, together with apparent feed waste (AFW):

$$TW = SW + DW + AFW$$

SW, DW and AFW outputs are biologically estimated by:

$$AFW = \text{Actual feed input} - \text{Theoretical feed requirement}$$

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Biological procedures based on the ADC for SW and comparative carcass analyses for DW were shown to provide very reliable estimates. Biological methods are flexible and capable of adaptation to a variety of conditions and rearing environments. It also allows estimation of the theoretical feed requirement and waste output under circumstances where it would be very difficult or impossible to do so with a chemical/limnological method (e.g. cage culture). Properly conducted biological and nutritional approaches to estimate aquaculture waste outputs are not only more accurate but also more economical than chemical/limnological method.

Factors Affecting Metabolic Waste Output

Month-End	Days	No. Fish	Weight (g/fish)	TGC	Total Biomass (kg)	Total Feed (kg)	Gain/ Feed	Temp (°C)	Flow Rate (L/min)
Initial		100000	10.00						
May	15	98900	12.05	0.184	1191.75	167	1.22	5.00	2500
Jun	30	95000	36.45	0.189	3462.75	2000	1.18	18.00	6000
Jul	31	95000	89.84	0.197	8534.80	4300	1.18	19.00	10000
Aug	31	94500	177.43	0.175	16767.14	7200	1.15	21.00	16000
Sep	30	94000	296.26	0.184	27848.44	9500	1.18	19.00	20000
Oct	31	93500	396.06	0.199	37031.61	7800	1.20	11.00	25000
Nov	30	93200	451.03	0.197	42036.00	4300	1.19	5.50	25000
Dec	31	93000	455.85	0.176	42394.05	400	1.12	0.50	25000
Jan	31	92000	460.77	0.178	42390.84	400	1.14	0.50	25000
Feb	28	91500	465.23	0.177	42568.55	370	1.11	0.50	25000
Mar	31	91200	470.39	0.184	42899.57	420	1.12	0.50	25000
Apr	30	91000	475.54	0.188	43274.14	420	1.12	0.50	25000
May	31	91000	534.65	0.200	48653.15	4500	1.20	5.00	30000
Jun	30	90800	783.37	0.204	71130.00	18500	1.22	18.00	50000
TOTAL	410 days			0.191		60277 kg feed	1.19		13.5 mill. m^3 water used

Fish production records from a field station

Factors Affecting Metabolic Waste Output

WASTE OUTPUT (Total Load Estimate)	Solid (kg)	Nitrogen (kg)	Phosphorus (kg)
Feed Wastage (2.2 %) *	1201	80.69	12.008
Solid	10610	356.49	212.194
Dissolved	-	1764.60	143.231
TOTAL	11811	2201.79	367.433
- per tonne fish produced	164.3	30.64	5.113
- % of dry matter fed	21.8 %	60.4 %	67.7 %
Average CONCENTRATION (mg/L) in EFFLUENT (13469 mill. L) during 410 days	0.877	0.163	0.027

Waste outputs and effluent quality from fish production operation in previous Table

* Actual amount of feed fed – Theoretical amount of feed required