NOMENCLATURE, TERMINOLOGY AND DEFINITIONS APPROPRIATE TO ANIMAL NUTRITION

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ABSTRACT

The paper attempts to present a comprehensive coverage of nomenclature, terminology and definitions appropriate to animal nutrition which are relevant to fish production. Particular focus is made to the expressions of energy and protein that are currently used, inter-conversion of energy values and methods of measuring protein quality. Of the energy systems, the metabolisable energy (ME) system is the most widely applied. Concerning proteins, digestible crude protein (DCP) and true protein are also widely used. Reference is also made to efficiency as it applies to the overall production process and especially to feed efficiency, including various measures of it. A glossary of common terms used in animal nutrition is also included.

INTRODUCTION

In a previous publication (Devendra, 1986), the general approaches to animal nutrition research and their relevance to fish production were discussed with reference to four objectives as follows :

(i) Identification and definition of the feed resources.

(ii) Assessment of nutritive value.

(iii) Utilisation in efficient and economic feeding systems, and

(iv) Determination of nutrient requirements.

The paper also referred to the significance of nutrient variables that influence production responses, the importance of feeding standards and a strategy for fish feed formulation. Reference is also made in this context to the publication by Cho, Cowey and Watanabe (1985) on the methodological details to research and development in fish nutrition.

In a continuation of the focus on fish nutrition, this paper is concerned with nomenclature, terminology and definitions appropriate to animal nutrition. The reference to these aspects has a bearing on an understanding of research in fish nutrition.

It is not proposed to deal exhaustively with all aspects of the subject since much of the information can be found in various books on animal nutrition, although this is likely to be scattered. Thus, for example, little or no reference will be made to identification and definition of the various types of agro-industrial by-products including non-conventional feeds, which are potentially useful as energy or protein feeds for fish. Attention will be focussed on the energy and protein systems in use, and the importance of efficiency in animal nutrition which may be relevance to fish nutrition.

EXPRESSIONS OF ENERGY

The following expresssions of energy are used :

Quantitatively, energy is the most important nutrient in the diet of animals. Several expressions of energy systems exist. It is now known that over a wide range of forages and concentrate feeds, the assessment of energy values using different systems is variable and inaccurate. In general, the efficiency of energy utilisation increases, with dietary energy density. This does not occur at a constant rate and is dependent on the physiological condition and function of the animals.

(i) Starch Equivalent (SE) - United Kingdom
(ii) The Scandinavian Fodder Unit (SFU) - Denmark
(iii) Fattening Fodder Units (FFU) - Denmark
(iv) The French system of Fodder Equivalent - France
(v) Rostock NEF system - Germany
(vi) Net Energy of lactation system - Netherlands
(vii) California system - USA
(viii) Total Digestible Nutrients (TDN) - USA
(ix) Metabolisable Energy (ME) - United Kingdom
(x) Digestible Energy (DE) - United Kingdom.

Alderman (1983) has reviewed the status of the newer European feeding systems and concluded that the ME value was basic to all systems. More recently, Alderman (1985) has also reviewed the different methods for the prediction of the energy value of compound feeds for ruminants, poultry and pigs. Of the systems in use, it is clear that the ME system is the most widely applied presently. It has become the preferred expression of feed value (MAAF, 1975; Van Eys, Vermorel and Bickel, 1978; ARC, 1980; Sibbald, 1982, Dewhurst et al., 1986) since the deduction of energy losses in urine and fermentation gases from DE provide a more accurate estimate of productive energy. ME can be calculated from DE from the equation ME = 0.81 DE based on methane and urine energy as a constant fraction (Armstrong, 1964).

Evidence that the ME system is superior to the SE system is seen in the results of the comparisons (Brabander et al., 1978; Hill, 1977). The former used 55 different diets for dairy cows to compare the total energy intake with each animal's requirement for maintenance and production within each system. It was found that the ME system fitted the actual energy requirements better than the SE system. Similar results were also reported by Hill (1977) for dairy cows. Both reports indicated that the SE system underestimated the energy requirements of the cows.

ME or DE for each type of animal is usually calculated from the average ME or DE in dry matter or from various published equations. For poultry, it can also be calculated from the average true ME (TME) using the method of Sibbald (1982). DE is calculated as follows :

DE = Gross energy of feed in DM x Gross energy digestion coefficient

ENERGY CONVERSIONS

It is appropriate to keep in perspective that it is feasible to convert different feed units in terms of energy, with the full knowledge that these are approximations and subject to error. The interconversion of energy values enables the expression of nutritive values of the same feed in different locations and more particularly, comparison of the results of nutrition research from different laboratories and locations. The following conversions are important :

1 kg starch equivalent (SE)	=	5.082 Mcal DE
	=	4.167 Mcal ME
	=	1.15 kg TDN
	=	1.10 kg DOM
	=	2.356 kcal NE
1 kg of Scandinavian feed unit (SFU)	=	2.820 Mcal ME
1 feed fattening unit (FFU)	=	1.650 Mcal ME
1 kg TDN	=	4.409 Mcal DE
	=	3.620 Mcal ME
1 kilo joule (kJ)	=	0.239 kcal
1 kcal	=	4.184 joule
1 Mcal	=	4.184 MJ
1 Mcal ME	=	0.81 Mcal DE

EXPRESSIONS OF PROTEIN

A number of expressions of protein value exist. These are :

(i) Digestible crude protein (DCP)
(ii) True protein (TP)
(iii) Protein efficiency ratio (PER)
(iv) Net protein retention (NPR)
(v) Gross protein value (GPV)
(vi) Protein replacement value (PRV)
(vii) Biological value (BV)
(viii) Net protein utilisation (NPU)
(ix) Net protein value (NPV)
(x) Biological assays
(xi) Protein equivalent (PE)
(xii) Degradibility

It is perhaps appropriate to focus on those methods that are more relevant. DCP for example is not an entirely satisfactory method of expressing protein value since the efficiency with which the absorbed protein is used differs from one species to another and even breeds within a species. It also does not indicate the usefulness to the animal. In comparison to DCP, true protein values are also used. The latter separates out the non-protein nitrogen (NPN) portion within the total protein. DCP is calculated as follows :

$$(a)\quad DCP = \frac{\%\ \text{protein in DM} \times \text{Digestibility coefficient of protein}}{100}$$

In addition to DCP, and in view of the limitations in it, other methods are used as follows :

$$(b)\quad PER = \frac{\text{Gain in body weight (g)}}{\text{Protein consumed (g)}}$$

$$(c)\quad NPR = \frac{\text{Weight gain of TPG - weight loss of NPG}}{\text{Weight of protein consumed}}$$

where TPG = group fed on test protein
NPG = non-protein group

$$(d)\quad GPV = \frac{A}{A_0}$$

where A = g increased weight gain/g test protein
A_0 = g increased weight gain/g casein

$$(e)\quad PRV = \frac{A - B}{\text{N intake}}$$

where A = N balance for standard protein in mg/basal kJ
B = N balance for protein under investigation in mg/basal kJ

(f) BV

$$BV = \frac{\text{N intake - (faecal N -MFN) - (urinary N - EUN)}}{\text{N intake - (faecal N - MFN)}}$$

where MNF = Metabolic faecal nitrogen
EUN = Endogenous urinary nitrogen

(g) NPU

NPU = Digestibility x BV

(h) NPV

NPV = NPU x % crude protein

$$(i)\quad PE = \frac{\%\ DCP + \%\ \text{Digestible true protein}}{2}$$

Of these expressions, GPV is the most commonly used biological method for evaluating proteins. GPV measures the ability of proteins to supplement diets containing mainly cereals. The use of protein degradability is a relatively recent one, and one which is more appropriate to ruminant nutrition. The extent of the degradability of a protein source within the rumen reflects its usefulness in terms of amino acid supply posterior to the rumen. This is influenced by such factors in solubility and also tannin content.

EFFICIENCY

With reference to dietary nutrient supply to meet the requirements for maintenance and production, and the manner in which these are utilised, the final expression of these aspects is reflected in the general term efficiency. It is pertinent therefore to briefly consider this issue.

Efficiency in animal and fish production is the sum total of a number of interacting factors, genetic and phenotypic. It is developed through research aimed at maximising genetic, nutritional and physiological potential of individual animal species. It is also dependent on improved management practices, reduced effects of the environment and disease factors.

The components which influence the measurement of efficiency are :

(i) Efficiency of feed conversion, which is influenced by the nutritional quality of the diet, level of feeding, processing of ingredients, use of feed additives, prices and genetic potential.

(ii) Ability to reproduce efficiently, which is the sum total of age at first breeding, conception rate, number of offspring born and breeding interval. Survival of the young and wastage in adult life are influenced by several factors of which environmental adaptation, management and disease resistance are particularly important.

(iii) Age, duration and size at maturity for biomass production.

(iv) Reduced disease incidence.

FEED EFFICIENCY

The efficiency with which farm animals convert feedstuffs into food for man is a subject of much interest, and has particular significance in animal and fish nutrition. In recent years, it is a subject that has received much attention (see for example Reid, 1970 and Holmes, 1971).

The efficiency of feed conversion is influenced by several factors and include inter alia inherent genetic capacity, diet quality, level of feeding, processing and level of ingredients used, potential response and price of the products. Related to these is the time-scale involved.

There are several measures of efficiency. The type of index used is influenced by type of units used. The indices below reflect the more common ones used in animal nutrition. Reference is made to each method as well as how each one is derived :

$$\text{(a) Apparent efficiency (meat)} = \frac{\text{Amount of meat produced}}{\text{Quantity of feed consumed}}$$

$$\text{(b) Gross efficiency (meat)} = \frac{\text{Apparent efficiency}}{\text{Dressing percentage}}$$

$$\text{(c) Gross energy (GE) \%} = \frac{\text{Edible energy}}{\text{Total GE consumed}} \times 100$$

$$\text{(d) Metabolisable energy (ME) \%} = \frac{\text{Edible energy}}{\text{Total ME consumed}} \times 100$$

$$\text{(e) Edible protein (\%)} = \frac{\text{Edible protein}}{\text{Total feed protein consumed}} \times 100$$

$$\text{(f) Edible protein (g/MJ ME)} = \frac{\text{Edible protein}}{\text{Total ME consumed (MJ)}}$$

$$\text{(g) Edible protein (g/MJ GE)} = \frac{\text{Edible protein}}{\text{Total GE consumed (MJ)}}$$

GLOSSARY OF TERMS

A wide variety of terms are used in animal nutrition associated with nomenclature, terminology, various expressions of dietary energy and protein, and measures of efficiency. It is impossible and also impractical to draw reference to all the terms used, however an attempt is made to bring together the ones that are more commonly used. Appendix 1 presents this compilation to reflect the range of terms used, an understanding of the use of the terms, with reference to description of research methodology, results and discussions appropriate to animal nutrition. It is hoped that this compilation will also be helpful to fish nutrition.

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APPENDIX I
GLOSSARY

Additives - Feed materials such as antibiotics, colouring matter, flavours, hormones and medicants.

Biological value (BV) - Of a protein is a measure of protein retention to protein absorption.

Cake - The residue that results from pressing seeds or meat to extract oil, fat and other liquids.

Calorie - The unit for measuring the energy in feeds.

1000 cal = 1 Kcal
1000 Kcal = 1 Mcal
1 cal = 4.184 joules (J)

Concentrate - Class of feeds that are low in crude fibre and high in total digestible nutrients such as cereal grains and high quality by-products like fish meal and groundnut cake. It is usually used to improve the total nutritive value of a diet for production.

Crude fibre - The ash-free residue of a food which remains after boiling for 30 minutes successively in 1.25% sulphuric acid and 1.25% sodium hydroxide. With most foods, crude fibre represents some 90 to 95% cellulose, the remainder being hemicellulose, lignin and other plant cell wall constituents.

Crude protein - Refers to the true protein component and all the nitrogen (N) in the feed. It is determined by multiplying the total N by 6.25; the latter represents the average N content in most foods.

Degradability - Of dry matter or of a protein is the measure of the extent to which it is degraded in the rumen of ruminants.

Digestibility - Is that proportion of a feed which is not excreted in the faeces and is assumed to be absorbed by the animal.

Digestible crude protein (DCP) - Refers to the portion of the dietary proteins which are digested and absorbed.

Digestible energy (DE) - The portion of the gross food energy (GE) minus the faecal energy that has been apparently absorbed. DE = (GE of feed per unit dry wt. x dry wt. of feed) - (GE of faeces per unit dry wt. x dry wt. of faeces).

Digestible nutrients - The portion of the dietary nutrients which is digested and absorbed by the animal body. These usually refer to carbohydrates, fats and proteins.

Dry matter (DM) - Refers to the moisture-free residue of any sample. It is determined by keeping a sample in an oven at 105°C until it reaches constant weight.

Essential amino acids (EAA) - Are amino acids which are essential to the animal and which the animal body cannot synthesize fast enough to meet the requirements. These include arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.

Energy feeds - Ingredients with less than 20% protein and less than 18% crude fibre.

Ether extract - Also called crude fat. The material extractable with any anhydrous solvent, for example petroleum spirit or di-ethyl ether. It contains neutral fats and all fat-soluble materials.

Feed efficiency - Refers to the ability with which animals can convert the feed consumed into edible and other products. Its accurate determination is dependent on the inputs used and outputs derived.

Feeding standards - Statements of the amounts of nutrients required by animals and fishes. The term is synonymous with nutrient requirements and allowances.

Gross energy (GE) - Is the amount of heat released from a feed when it is completely oxidised in a bomb calorimeter containing 25 to 30 atmospheres of oxygen.

Heat increment (HI) - Is the increase in heat production following consumption of a feed or ration when the animal is in a thermally neutral environment. It consists of increased heats of fermentation produced in the digestive tract as a result of microbial action and during intermediary metabolism and absorption. HI is wasted except when the temperature of the environment is below the animals critical temperature.

Intake - Refers to the amount of feed consumed and available for digestion, usually expressed in DM. Intake is the result of either restricted or ad libitum feeding.

Maintenance - State of energy equilibrium of an animal when there is no net gain or loss of energy in body tissues.

Meal - Describes the physical form of a feed that has been reduced to a particle size larger than that of flour.

Metabolisable energy (ME) - The portion of the gross food energy (GE) minus faecal energy, minus energy in the gaseous products of digestion minus urinary energy. ME = (GE of feed) - (GE of faeces + GE of gaseous products + GE of urine).

Minerals - Are elements that have a metabolic role in the body. They include macro-minerals and micro-minerals; the latter include trace minerals.

Net energy (NE) - Is the amount of energy used either for maintenance or for production or both. NE = ME - HI. NE is available for maintenance (NE_m) or production (NE_p). The latter refers to growth, fattening draught or in the production of milk, eggs and fibre.

Nitrogen-free extract (NFE) - The food fraction that is calculated as the difference between the dry matter of the sample and the sum of the determined ash, crude protein, ether extract and crude fibre. Its chief components are starches, variable amounts and lignin and hemicellulose. NFE (%) = 100 - % ash - % crude protein - % ether extract - % crude fibre.

Non-essential amino acids - Are amino acids which are not needed in the diet but which are essential to the animal eg. aspartic acid, alanine, cystine, glycine and proline.

Non-protein nitrogen (NPN) - Compounds which are not true protein in nature but contain N and can be converted to protein by bacterial action eg. urea and biuret.

Nutrient balance - Condition which described a diet that makes available various nutrients in the right amounts to fulfil the physiological needs of an animal to meet both maintenance and production requirements (growth, pregnancy, meat, milk, fibre, eggs or work).

Pellets	- Refers to physical form during which a feed or combination of feeds are compacted by mechanical means. Different size pellets can be made depending on die openings.
Pressed	- Process of compaction by pressure or extraction under pressure.
Protein quality	- Refers to the amount and ratio of amino acids in the protein.
Protein supplement	- Products which contain 20% or more protein from plant or animal origins.
Roughages	- Class of feeds, usually plant materials, that are very fibrous, bulky and contain usually more than 18% crude fibre. They are low in total digestible nutrients, such as straws and stovers.
Supplement	- A feed, either alone or in combination which is used to increase the availability of nutrients and also performance of animals. Can be an energy, protein, mineral and/or vitamin supplement.
Total digestible nutrients (TDN)	- Is the sum of all digestible organic materials (proteins, fibre, fat and NFE). TDN = Digestible crude protein x 1% + digestible crude fibre x 1% + digestible NFE x 1% and digestible ether extract x 2.25%.
True protein	- The portion of the protein source which is composed only of amino acids.
Vitamins	- Are important organic compounds in animal nutrition that are associated in enzyme systems and metabolism for various body functions.