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HIT AND TRIAL METHOD FOR ARTIFICIAL FEED FORMULATION

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Introduction

Feed formulation is a technique to be learnt and refined by experience. To date numerous descriptions have appeared in nutrition textbooks. The exercise taught over and over again is difficult to comprehend especially by the beginners. The purpose of this article is to describe and share some of this authors experience in teaching and learning feed formulation; mainly for aquatic animal research. Previous descriptions on the subject can be had from New, 1987 ad Houser and Akiyama 1997 among which New 1987 describes the subject with a lay man in mind. Here again, the emphasis is to describe the technique in the simplest way by which it is presumed that, beginners in the subject of aquatic animal nutrition shall be benefited.

Let us start by organising the data or information required for the exercise. The check list can be as follows.

1. List of feed ingredients available for the formulation and their proximate chemical composition and cost.
2. Specifications of the feed to be formulated in terms of protein, lipid, fiber, soluble carbohydrates (NFE or nitrogen free extract) vitamins and minerals etc.
3. Safe levels and suitability of the levels of incorporation of certain materials for the animals to be fed.

The primary step in formulating a feed is to organise this information in a manner in which it is convenient to the person doing the formulation. Readymade tables of the aforementioned information are available. These tables may be too huge to be referred to every now and then. Hence, it is advisable to construct a Table to suit ones own convenience as follows. The Table1, shown below, includes a list of feed ingredients commonly used in and around Cochin, India and their retail cost.

Table 1. **List of feed ingredients commonly used in and around Cochin, India and their retail cost**

Ingredients	DM[1]	CP[2]	EE[3]	CF[4]	NFE[5]	Ash	AIA[6]	Cost [Rs./kg]
Fish meal	95.16	68.50	8.49	-	0.61	17.56	2.71	50.00
Shrimp meal	92.51	67.45	3.29	-	5.27	16.50	4.39	60.00
Clam meal	94.37	59.79	13.01	-	15.10	6.47	1.94	50.00
GNOC	94.55	43.75	8.13	5.49	30.10	7.08	2.36	10.00
Tapioca flour	87.18	2.82	0.29	1.79	80.26	2.02	0.10	7.00

[1]Dry matter, [2]Crude Protein, [3]Ether Extract, [4]Crude Fibre, [5]Nitrogen-Free Extractives, [6]Acid Insoluble Ash

The best bank of this information would be ones own analysis of the material if he/she has access to analytical facility. If not, samples can be got analysed from approved laboratories in the government sector or private sector. Government laboratories providing this service are (1) Nutrition laboratory of Marine Biotechnology Divison at CMFRI, Cochin – Write to The Director, CMFRI, P.O.Box 1603, Tatapuram (P.O.), Ernakulam, Cochin-682 014, Kerala (2) Director, Central Institute of Fisheries Technology (CIFT), Matsyapuri P.O., Willingdon Island, Ernakulam Kochi – 682029. (3) Animal feed quality control laboratory (AFQCL), TANUVAS, Namkkal, Tamil Nadu. – Write to, Prof. and Head, AFQCL, Veterinary College and Research Institute, Namakkal, Tamilnadu.

A fair understanding of the table containing the compositional information is a definite prerequisite before proceeding any further. The head in which the nutrient composition is quantified can be further described as,

1. DM Dry matter-indicates the total nutrient content excluding water.
2. CP Crude protein-indicates the total protein content inclusive of non-protein nitrogenous substances also.
3. EE Ether extract or crude fat indicates the total fat content which may include other fat soluble substances.
4. CF Crude fibre-indicates the cellulose content or the indigestible (for simple stomached) carbohydrate content.
5. NFE Nitrogen free extract or the total soluble/digestible carbohydrate content is contained in this fraction.
6. Ash Indicates the total content of mineral salts
7. AIA Acid insoluble ash indicates the indigestible impurities/adulterants in feed material which are mainly sand and silica

With the extensive use of computers it is desirable that if this information is fed into a computer in a Microsoft excel spread sheet available in the MS Office; it would be helpful in avoiding repetitive calculations which my be required if a simple calculator is used.

Now, let us get ahead with the computation *per se*. Pearson square method used for blending two ingredients or products to attain a specific nutrient concentration until the advent of computers is not explained here. This is because of the basic drawback of this method to blend only two ingredients at a time. When more than two ingredients need to be blended multiple Pearson squares have to be used or grouping of ingredients based on criteria like 'protein rich' and 'energy rich' has to be adopted. Simple ways of doing it is described by Ali (1987), New (1987) and a detailed review is available in Church and Nipper (1984).

The method intended to be described here in detail is commonly known as the hit and trial method which is not only convenient but also clears the concept of blending of feed ingredients/products in definite proportions and the resultant changes it brings about in the blend.After organising the data bank to be used for the formulation the next step is to define the requirement or composition of the feed to be made.Taking marine shrimp as an example, let us assume the requirement in terms of nutrients for animals grown in culture ponds at a stocking density of less than 5 animals per square meter as protein $\geq$35%, fat not more than 7%, fibre < 3%, soluble carbohydrates (NFE) 20-40% ash $\leq$ 15%, AIA $\leq$ 3% containing 340 – 360 kilocalories/100g.

Let us also fix that our feed mix should not cost more than Rs.30/-.

In the spread sheet where the information regarding composition and cost if fed another portion of the spread sheet involving the required number of rows and columns can be used for computation as shown in Table 2 below.

Table 2. Proximate composition of the feed ingredients, approximate cost (Rs/kg)

Ingredients	Cost Rs./kg	DM	CP	EE	CF	NFE	Ash	AIA
Fish meal	40.000	95.160	68.50	8.49		0.61	17.56	2.71
Shrimp meal	60.000	92.510	67.45	3.29		5.27	16.50	4.39
Clam meal	25.000	94.370	59.79	13.01		15.10	6.47	1.94
GNOC	10.000	94.550	43.75	8.13	5.49	30.10	7.08	2.36
Tapioca flour	14.000	87.180	2.82	0.29	1.79	80.26	2.02	0.10
Oil	50.000							
Cholesterol	100.000							
Lecithin	100.000							
Vitamin mix.	75.000							
Mineral mix.	30.000							

Ingredients	% Inclusion	Incl. Cost [Rs./kg]	CP	EE	CF	NFE	Ash	AIA
Fish meal	0.200	8.000	13.70	1.70	0.00	0.12	3.51	0.54
Shrimp meal	0.200	12.000	13.49	0.66	0.00	1.05	3.30	0.88
Clam meal	0.200	5.000	11.96	2.60	0.00	3.02	1.29	0.39
GNOC	0.200	2.000	8.75	1.63	1.10	6.02	1.42	0.47
Tapioca flr.	0.090	1.260	0.25	0.03	0.16	7.22	0.18	0.01
Oil	0.050	2.500		5.00				
Cholesterol	0.005	0.500						
Lecithin	0.005	0.500						
Vitamin mix.	0.030	2.250						
Mineral mix.	0.020	0.600						
Total cost/nutrients	1.000	**34.610**	**48.15**	**11.61**	**1.26**	**17.44**	**9.70**	**2.29**
GE kcal/100g			264.83	105.65		71.50	-	**41.99**
DE kcal/100g			199.63	41.76		33.05	-	**74.44**

Ingredients	% Inclusion	Incl. Cost [Rs./kg]	CP	EE	CF	NFE	Ash	AIA
Fish meal	0.150	6.000	10.28	1.27	0.00	0.09	2.63	0.41
Shrimp meal	0.150	9.000	10.12	0.49	0.00	0.79	2.48	0.66
Clam meal	0.150	3.750	8.97	1.95	0.00	2.27	0.97	0.29
GNOC	0.200	2.000	8.75	1.63	1.10	6.02	1.42	0.47
Tapioca flr.	0.240	3.360	0.68	0.07	0.43	19.26	0.48	0.02
Oil	0.050	2.500		5.00				
Cholesterol	0.005	0.500						
Lecithin	0.005	0.500						
Vitamin mix.	0.030	2.250						
Mineral mix.	0.020	0.600						
Total cost/nutrients	1.000	**30.460**	**38.79**	**10.41**	**1.53**	**28.43**	**7.98**	**1.85**
GE kcal/100g			213.33	94.77		116.56	-	**24.66**
DE kcal/100g			158.03	35.34		53.99	-	**47.36**

The trial to blend the ingredients available can be started by assigning the number of parts of a particular ingredient or it can be expressed as percentage inclusion. Knowledge of the safe levels of incorporation of a particular ingredient, cost, gelling properties, pelletability, bulk density etc., aids in assigning the number of parts of a particular ingredient. Let us start with assigning 20 parts of fishmeal, 20 parts of shrimp meal, 20 parts of clam meal, 20 parts of GNOC and 5 parts of oil which totals to 85 parts per 100. Out of the remaining 15 parts 3 parts of mineral mixture and 2 parts of vitamin mixture may be assigned. Since the dietary essentiality of cholesterol and phospholipids especially lecithin is proven in marine shrimps they may be provided at levels of 0.5% each making the total mix 91 parts per 100. The remaining nine parts can be either filled up with inert filler, filler with binder or an energy source like tapioca flour.

Now let us examine the nutrient profile (in %) of the mix by finding out the contribution of 20% fishmeal to the formulated feed as follows.

Crude protein (CP) available from 20% fish meal (FM) = CP in FM x 20/100
= 68.5 x 20/100
= 13.70

Ether extract (EE) or crude fat available from FM = EE in FM x 20/100
= 8.49 x 20/100
= 1.70

Crude fiber (CF) available from FM = 0

Nitrogen free extract (NFE) or soluble carbohydrates

available from FM = NFE in FM x 20/100
= 0.61 x 20/100
= 0.12

Ash (total minerals) available from FM = Ash in FM x 20/100
= 17.56 x 20/100
= 3.51

Acid insoluble ash (AIA) or inert material contributed by FM = AIA in FM x 20/100
= 2.71 x 20/100
= 0.54

Similarly gross energy (GE) is the quality of the feed, which indicates the amount of heat liberated when the material is burnt completely and digestible energy (DE) is that portion of the energy available to the animal to which it is fed. Technically it is the GE – energy lost as faeces or faecal energy. Standard values are in use for converting protein, fat and carbohydrate content. The values recommended by aquaculture coordination and development programme (ADCP, 1983) are used here which are as follows.

Nutrient	Gross energy (GE)kcal/g	Digestible energy (DE)	kcal/g
Protein	5.5	Animal protein Vegetable protein	4.25 3.8
Fat	9.1		8.0
Carbohydrate	4.1	Animal carbohydrate Vegetable carbohydrate	3.0 2.0

The total GE and DE content of the blend is calculated by multiplying the total CP, EE and NFE contents with these values. In the Excel spread sheet the formulae may be entered in the cell right below CP as = A1*0.2, where A1 is the cell number which contains the % CP of fishmeal. If we are working with a calculator and a work sheet these values have to be calculated as shown above and entered in the respective cells. However, in and Excel worksheet this formula if copied using the **+** sign appearing on the right hand bottom corner of the cell from which we intend to copy the formula, these calculations can be completed in no time. Similarly, for all ingredients the respective formulae may be copied and the work sheet may be filled.

The last step is to total the individual nutrient components in the bottom row for which the formula in = sum (cell No.: cell No.) where the first cell number is the cell from which the totalling should start and the second cell number is the cell from which the totalling should end. Thus, we get the final composition and cost of the feed mix, which may or may not comply with the requirements we had defined.

After completion of this we have at hand a base form, which we work, through the innumerable permutations and combinations to achieve the required nutrient specifications and cost. If a calculator and work sheet are the tools available we have to use several worksheets to manipulate the computations. In the Excel worksheet, once a formulation is made, just by altering i.e., increasing or decreasing the part/100 figures all the corresponding figures change automatically.

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