CHAPTER V

FEED FORMULATION WITH THE SILAGE AND ANALYSIS

FOR NUTRITIONAL COMPOSITION OF THE DIETS
FEED FORMULATION WITH THE SILAGE AND ANALYSIS FOR NUTRITIONAL COMPOSITION OF THE DIETS

Huet (1972) classified fish food into natural food and artificial feed. The artificial feed, used either as main or supplementary diet in aquaculture, has been further differentiated into vegetative feed, feed of animal origin and dry concentrated feed. A fourth one, namely wet feed formulate, can also be differentiated.

The subject of artificial feeding in aquaculture has been extensively reviewed by Hora and Pillay (1962), Ling (1967), Shell (1967), Hickling (1971), Khan (1971), Halver (1972), Huet (1972), Sneed et al. (1972), Jhingran (1975) and Rajyalakshmi et al. (1980).

Reports on the several aspects of artificial fish feed are many. Various fodder plants were tried as feed for carps (Bondi et al., 1957). Algae (Spirulina platensis and Spirogyra sp.) were evaluated as feed for Ictiobus cyprinellus, Tilapia aurea and Ctenopharyngodon idella (Stanley and Jones, 1976). Single cell proteins were fed to mirror carp fingerlings (Atack et al., 1979) and the duck weed Lemma gibba was found to be a good feed for tilapia in a recirculating culture system (Gaigher, 1984).
While *Artemia* was found to be a good food for cultured *Cyprinus carpio* L. by Bryant and Matty (1980), processed piggery waste appeared promising in the trials carried out by Watson (1985).

Diverse materials like algae, petroleum protein, the filamentous fungus *Geotrichum candidum*, bacterial protein, mustard seed cake, plant proteins like copra and groundnut expeller cakes, *Leucaena* leaves, solvent extracted meals of soya, rapeseed and cottonseed and broad bean were evaluated either as feed ingredients or protein replacements in dry feed concentrates for trout, tilapia and common carp (Singh and Kuljeet Bhanot, 1970; Chakrabarty and Kar, 1975; Cruz and Laudencia, 1978; Dabrowski *et al.*, 1980; Kaushik and Luquet, 1980; Mahnken *et al.*, 1980; Capper *et al.*, 1982; Jackson *et al.*, 1982; Viola *et al.*, 1982; Granner and Hofer, 1985).

Powdered brackish water macrophytes (Radhakrishnan, 1979), dry poultry droppings (*Devataj et al.*, 1979) and slaughter-house offal (Verghese and Singh, 1979) were tried as ingredients in the formulation of pelleted fish feeds. Clam meat, silkworm pupae, shrimp waste and fish meal have been used for pelleted feed making for feeding *Macrobrachium rosenbergii* (Ravishankar and Keshavanath, 1986).

The most common ingredients which have been used as supplementary diet for common carp and Indian major carps, are the rice bran and oil cake. This feed combination was
termed as 'traditional feed' by Jhingran (1975) and 'conventional feed' by Jayaram and Shetty (1979).

Casein silage had been tried as feed for salmonids (Åsgård and Austreng, 1985). Fish silage was also used as a dietary ingredient for salmon (Jackson et al., 1984a; 1984b) and common carp (Wood et al., 1985).

While the effect of pH of feeds on amino acid utilization by channel catfish was studied by Wilson et al. (1977), the effect of different acidified wet feeds on the growth rate of rainbow trout was evaluated by Rungruangsaenk and Utne (1981).

Evaluation of a test diet or an ingredient has been found better when the diet was pelleted and fed to the candidate fish species in a controlled system, than by giving the diet as wet or powdered feed in an open culture system. Therefore, in the present study, efforts were directed to use the weed silage as an ingredient in fish feed, after compounding it with other ingredients and preparing dry pellets out of it.

Several reports are available on different feed formulations, pelletization and their acceptance by fishes viz. common carp, Indian carps, tilapia, trouts, yellow-finned black porgy and prawns (Jayachandran and Paul Raj, 1976; Sehgal et al., 1976; Kanaujia, 1978; Ringangaonkar, 1978; Miller, 1979; Rajyalakshmi et al., 1979; Reinitz and Hitzel, 1980; Jafri et al., 1981; Rajyalakshmi et al., 1982).

Materials like agar, alginates, carageenan, guar, locust
been gum, gelatins, cellulosics and tapioca flour have been tested for their binding ability (Huet, 1972; Rajyalakshmi et al., 1980; Storebakken, 1985; Wood et al., 1985).

Stability of feeds in water, loss of nutrients by leaching (especially crude protein) and pellet softening are critical factors related to feed acceptance by fish and their growth. Various feeds were examined for pellet extrusion properties and its durability, water absorption and nutrient leaching on application to water, in the evaluation trials conducted by Goldblatt et al. (1980), Hilton et al. (1981) and Wood et al. (1985).

It was found that the size of the feed pellet should suit the mouth opening, feeding habit and the stage of the fish selected for the feeding trial (Baker et al., 1972; Jackson and Capper, 1982; Jackson et al., 1982; Anderson et al., 1984; Dabrowski and Bardega, 1984; Wood et al., 1985).

Selection of feed ingredients and their proportion and inclusion levels in the artificial diet are based on the nutritional requirements of the fish and numerous investigations have been conducted on the nutritional requirements of economically important crustaceans and fin fishes.

Migita (1937), Balazs and Ross (1976), Colvin (1976), Rajyalakshmi (1978), Rajyalakshmi et al. (1979; 1980), Bages and Sloane (1981), Boghen and Castell (1981) and Ravishankar and Keshavanath (1986) studied the nutritional requirements,
mainly protein (and different sources of protein) of prawns like Macrobrachium rosenbergii, Penaeus indicus and P. monodon, lobsters, other crustaceans and some cultured fish species. Protein nutrition in turbot (Scophthalmus maximus), puffer fish, Tilapia aurea and carp was examined in detail by Aoe et al. (1970; 1974), Wu and Jan (1977), Bromley (1980) and Kanazawa et al. (1980 a; 1980 b). Studies on the amino acid requirement and utilization by carp, channel cat-fish, Tilapia zillii, rainbow trout and Sarotherodon mossambicus were made by Aoe et al. (1970), Nose et al. (1974), Wilson et al. (1977), Mazid et al. (1978), Nose (1979), Ogino (1980) and Jackson and Capper (1982).

The requirements of dietary fibre, carbohydrates, essential fatty acids and gross energy and their source materials were investigated by Adron et al. (1976), Mazid et al. (1979), Kanazawa et al. (1980 a) and Anderson et al. (1984), in the feeding trials with turbot and tilapia.

Diet supplementation of ascorbic acid for Indian major carp Cirrhina mrigala (Mahajan and Agrawal, 1980), copper for channel cat fish (Murai et al., 1981) and phosphorus for common carp (Hepher and Sandbank, 1984) were elaborately studied. Das (1959; 1967) studied the B_{12} and micronutrient requirements of carp fry. Jhingran (1975) has reviewed reports on the vitamin and mineral requirements of carps. Anderson et al. (1984) successfully tried vitamin and mineral additives at 2% level in their evaluatory fish feeding trials.
All the above reports were taken into consideration for the formulation of seven experimental fish diets, with weed silage inclusion levels of 0, 33, 50 and 66%.

MATERIALS AND METHODS

Diet preparation

Jhingran (1975) observed that the most commonly administered supplementary feed for the cultured Indian carps are rice bran and ground nut oil cake, given at 1:1 ratio. Based on this, a 'traditional feed' (TF) was formulated by mixing rice bran, powdered groundnut oil cake and tapioca flour at 40, 40 and 16% levels, respectively. Tapioca flour was added as a binder. From the above mix, 1/3, 1/2 and 2/3 portions were removed and replaced with the 120 days old wet silage of the weeds. Their wet inclusion levels, therefore, were 33, 50 and 66% which corresponded to the dry inclusion levels of 20, 35 and 50%, respectively. With three inclusion levels for each weed, the resultant six feed formulates were designated as S33, S50, S66, WH33, WH50 and WH66 (Plate VII b). To all the seven formulates (including TF) vitamin-mineral mix prepared from Supplevite-M of Sarabhai Chemicals (India) was added at 2% level. Composition of the seven feed formulates including the vitamin and minerals added are detailed in table 14. Three inclusion levels for each weed silage were taken up for formulation, so that they could be
Table 14. Percentage composition of feed formulates (Fresh weight basis).

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Test diets</th>
<th>S33</th>
<th>S50</th>
<th>S66</th>
<th>WH33</th>
<th>WH50</th>
<th>WH66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvinia silage</td>
<td>-</td>
<td>33</td>
<td>50</td>
<td>66</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Water hyacinth silage.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>33</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Groundnut oil® cake</td>
<td>40</td>
<td>32</td>
<td>25</td>
<td>25</td>
<td>35</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Rice bran®</td>
<td>40</td>
<td>18</td>
<td>15</td>
<td>-</td>
<td>20</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Tapioca flour</td>
<td>18</td>
<td>15</td>
<td>8</td>
<td>7</td>
<td>10</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Vitamin-mineral mix.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

@ Groundnut oil cake contained 41.0% crude protein.
# Rice bran contained 12.81% crude protein.
* Vitamin-mineral mix provided the following nutrients per kg of feed:
  Vitamin A, 38,461.5 I.U.; Vitamin D₃ 7,692.3 I.U.;
  Vitamin B₂, 15.38 mg; Vitamin E, 5.77 Units; Vitamin K,
  7.69 mg; calcium pantothanate, 19.23 mg; nicotinamide,
  76.92 mg; Vitamin B₁₂, 0.046 mg; choline chloride, 1.15 g;
  calcium 5.77 g; manganese, 211.54 mg; iodine, 7.69 mg;
  iron, 57.69 mg; zinc, 115.38 mg; copper, 15.38 mg;
  cobalt, 3.46 mg; ascorbic acid, 769.23 mg.
compared to the TF taken as the zero level of inclusion.

The aim was to prepare isonitrogenous and isocaloric diets. Hence, the seven test diets were formulated in such a way as to have around 25% crude protein and gross energy level of about 16 MJ/kg.

Though Viola et al. (1982) recommended 33% of crude protein level in diets for carps reared in the intensive culture system, such a high level of protein was considered not desirable in the present test diets as it did not represent the true level of protein in the study material (weed silage) which was low in crude protein (10 to 16%). At the same time, with a low protein test diet, proper growth response could not be achieved. Hence, a compromise level of 25% crude protein was finalised. The addition of oil cake to the diet allowed about 33 to 66% increase in the protein status of the test materials.

The ingredients were well macerated and mixed in a large electric blender and extruded manually into strands through a hand squeezer with a die head of 2 mm sieve. Diets $S_{50}$, $S_{66}$, $WH_{50}$ and $WH_{66}$ could not be extruded through the squeezer. So the paste was flattened out into 2 mm thick flakes. Feed strands and flakes were air dried under ambient conditions and crumbled. Fractions less than 2 mm and between 2 and 4 mm were separated using appropriate screens and stored in polythene bags.
Chemical analysis of the feed formulations

The seven feed formulations (test diets) were subjected to chemical analysis to find out their proximate compositions. The moisture content of the feeds was found out by drying them at 65°C in a hot-air oven.

Crude fibre, ether extract and ash contents of the feed diets were determined by A.O.A.C. methods (Horwitz, 1975). The crude protein was estimated by colorimetric determination of nitrogen after the microkjeldhal digestion and conversion by factor 6.25 (Jackson, 1973). In order to know the measure of the degree of hydrolysis of the feed protein into other components such as amino acids and short chain peptides, the feeds were extracted in alcohol and the samples analysed for non-protein nitrogen (NPN) content (as N not precipitated by trichloracetic acid) by Ninhydrin method (Moore and Stein, 1948). The values are expressed as percentage of total nitrogen.

Amino acid levels in the experimental diets were calculated from the values of the two weeds, groundnut oil cake, rice bran and tapioca according to the proportions at which they were added. The calculations of the amino acid contents of the ingredients used were based on the reports of Jackson and Capper (1982) for ground nut oil cake, Indian Standards (1975 a) for rice bran and Muindi and Hanssen (1981)
for tapioca, for crude protein levels of 41, 13 and 2%, respectively.

Nitrogen free extract (NFE) was calculated by subtracting the sum percentage of crude protein, crude fibre and ash from the dry matter of the feed, taken as 100 and expressed in percentage.

Gross energy values of the feeds were calculated using the results of feed analysis and based on the following energy requirements (Halver, 1972; Anderson et al., 1984): fats, 39.2 MJ/kg; protein, 23.6 MJ/kg; carbohydrates, 16.74 MJ/kg.

Test for loss of crude protein by leaching in the formulated feeds

Feed formulations were tested for the loss of crude protein on immersion and disturbance in water, as per the method described by Wood et al. (1985). Each feed was placed in three of No.1 sintered crucibles. The crucibles were filled with distilled water which was allowed to flow freely without application of suction. Water was added continuously to maintain the initial level. At 5, 15 and 30 minutes intervals, one set each of the seven crucibles containing the test diets, was removed, water drained off and the crucibles with the feeds were dried at 60°C overnight. The crude protein levels of the residues were determined as described earlier. The leaching loss was expressed as percentage of the original crude protein in feed.
RESULTS

The proximate composition and gross energy content of the traditional feed (TF) and the six silage feed formulations are tabulated in Table 15.

Proximate composition

The moisture levels of the seven test diets were between 5.60% (S33) and 8.25% (TF).

Ether extract of diet TF was 8.86% and for the *Salvinia* silage inclusion diets, it was around 7.00% and for water hyacinth diets around 10.00%, on dry matter basis.

Crude fibre content of diet TF was 12.99%. As the inclusion level of *Salvinia* silage increased in diet, the fibre content also increased from 15.17% (S33) to 19.77% (S66). But the levels in water hyacinth diets were more or less the same (around 13.00%).

Nitrogen free extract ranged from 36.05% (S66) to 42.30% (S33). Least values were obtained in 66% silage inclusion diets.

Crude protein levels of all the test diets were around 25.0%. The lowest value was in diet S50 (24.36%) and the highest in WH33 and WH66 (26.64%).

The non-protein nitrogen content, expressed as percentage of total crude protein nitrogen, ranged from 41.19% in
### Table 15. Chemical composition and gross energy content of feed formulates.

<table>
<thead>
<tr>
<th>Test diets</th>
<th>TF</th>
<th>S33</th>
<th>S50</th>
<th>S66</th>
<th>WH33</th>
<th>WH50</th>
<th>WH66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (% FW as fed)</td>
<td>8.25</td>
<td>5.60</td>
<td>6.62</td>
<td>7.20</td>
<td>6.47</td>
<td>7.09</td>
<td>6.97</td>
</tr>
<tr>
<td>Ether extract (% DM)</td>
<td>8.86</td>
<td>7.49</td>
<td>6.93</td>
<td>7.37</td>
<td>11.34</td>
<td>9.36</td>
<td>10.64</td>
</tr>
<tr>
<td>Nitrogen-free extract (% DM)</td>
<td>41.60</td>
<td>42.30</td>
<td>38.96</td>
<td>36.05</td>
<td>37.72</td>
<td>37.45</td>
<td>38.06</td>
</tr>
<tr>
<td>Crude protein (% DM) (N x 6.25)</td>
<td>25.88</td>
<td>25.12</td>
<td>24.36</td>
<td>25.88</td>
<td>26.64</td>
<td>25.88</td>
<td>26.64</td>
</tr>
<tr>
<td>Non protein nitrogen (as % of total N)</td>
<td>41.19</td>
<td>44.97</td>
<td>50.34</td>
<td>54.95</td>
<td>46.00</td>
<td>53.35</td>
<td>58.04</td>
</tr>
<tr>
<td>Gross energy (MJ/kg)</td>
<td>16.54</td>
<td>15.95</td>
<td>15.00</td>
<td>15.03</td>
<td>17.04</td>
<td>16.05</td>
<td>16.33</td>
</tr>
</tbody>
</table>

**FW** - Fresh weight.

**DM** - Dry matter.
diet TF to 58.04% in diet WH_{66}. The content increased with the increase of silage inclusion level in diet.

While the levels of ash content of diets TF, S_{33}, S_{50}, S_{66} and WH_{33} were between 9.92% (S_{33}) and 11.72% (WH_{33}), diets WH_{50} and WH_{66} had slightly higher values (13.82 and 14.78%, respectively).

**Gross energy content**

The seven test diets prepared were almost isocaloric in nature, having a difference of only 2 MJ/kg between the lowest value of 15.00 MJ/kg in the diet S_{50} and the highest of 17.04 MJ/kg in the diet WH_{33}.

**Amino acid content**

The calculated levels of amino acids in the seven experimental fish diets on percentage basis were compared with the dietary essential amino acid requirements for carp, as suggested by Ogino (1980). They are furnished in table 16. It could be seen from the table that the levels of isoleucine, leucine, cystine, tyrosine and histidine in the test diets were more or less the same as that of carp requirement. While phenylalanine of TF was in required level, the content was low in *Salvinia* and water hyacinth silage diets. Excepting the diet S_{66}, all the rest of the diets contained more than the required level of Arginine (1.5%). The levels of lysine,
<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Diet</th>
<th>TF</th>
<th>S33</th>
<th>S50</th>
<th>S66</th>
<th>WH33</th>
<th>WH50</th>
<th>WH66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td></td>
<td>0.71</td>
<td>0.86</td>
<td>0.94</td>
<td>1.05</td>
<td>0.97</td>
<td>1.03</td>
<td>1.20</td>
</tr>
<tr>
<td>Leucine</td>
<td></td>
<td>1.30</td>
<td>1.20</td>
<td>1.15</td>
<td>1.16</td>
<td>1.35</td>
<td>1.25</td>
<td>1.36</td>
</tr>
<tr>
<td>Lysine</td>
<td></td>
<td>0.73</td>
<td>0.66</td>
<td>0.61</td>
<td>0.61</td>
<td>0.78</td>
<td>0.74</td>
<td>0.82</td>
</tr>
<tr>
<td>Methionine</td>
<td></td>
<td>0.18</td>
<td>0.21</td>
<td>0.22</td>
<td>0.25</td>
<td>0.22</td>
<td>0.22</td>
<td>0.26</td>
</tr>
<tr>
<td>Cystine</td>
<td></td>
<td>0.34</td>
<td>0.25</td>
<td>0.21</td>
<td>0.18</td>
<td>0.30</td>
<td>0.24</td>
<td>0.25</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td></td>
<td>1.00</td>
<td>0.83</td>
<td>0.73</td>
<td>0.69</td>
<td>0.85</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>Tyrosine</td>
<td></td>
<td>0.87</td>
<td>0.70</td>
<td>0.61</td>
<td>0.56</td>
<td>0.73</td>
<td>0.56</td>
<td>0.55</td>
</tr>
<tr>
<td>Threonine</td>
<td></td>
<td>0.56</td>
<td>0.51</td>
<td>0.48</td>
<td>0.48</td>
<td>0.58</td>
<td>0.53</td>
<td>0.58</td>
</tr>
<tr>
<td>Valine</td>
<td></td>
<td>0.90</td>
<td>0.82</td>
<td>0.78</td>
<td>0.78</td>
<td>0.91</td>
<td>0.83</td>
<td>0.90</td>
</tr>
<tr>
<td>Arginine</td>
<td></td>
<td>2.43</td>
<td>1.84</td>
<td>1.52</td>
<td>1.34</td>
<td>2.08</td>
<td>1.63</td>
<td>1.63</td>
</tr>
<tr>
<td>Histidine</td>
<td></td>
<td>0.51</td>
<td>0.42</td>
<td>0.37</td>
<td>0.35</td>
<td>0.63</td>
<td>0.64</td>
<td>0.74</td>
</tr>
<tr>
<td>Alanine</td>
<td></td>
<td>0.91</td>
<td>0.80</td>
<td>0.73</td>
<td>0.72</td>
<td>0.90</td>
<td>0.80</td>
<td>0.86</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td></td>
<td>2.27</td>
<td>1.93</td>
<td>1.73</td>
<td>1.67</td>
<td>2.12</td>
<td>1.79</td>
<td>1.88</td>
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<tr>
<td>Glutamic acid</td>
<td></td>
<td>4.30</td>
<td>3.75</td>
<td>3.43</td>
<td>3.37</td>
<td>4.28</td>
<td>3.81</td>
<td>4.11</td>
</tr>
<tr>
<td>Glycine</td>
<td></td>
<td>1.22</td>
<td>1.00</td>
<td>0.87</td>
<td>0.82</td>
<td>1.12</td>
<td>0.93</td>
<td>0.96</td>
</tr>
<tr>
<td>Proline</td>
<td></td>
<td>1.04</td>
<td>0.99</td>
<td>0.95</td>
<td>0.98</td>
<td>0.96</td>
<td>0.81</td>
<td>0.84</td>
</tr>
<tr>
<td>Serine</td>
<td></td>
<td>1.05</td>
<td>0.86</td>
<td>0.75</td>
<td>0.70</td>
<td>1.03</td>
<td>0.90</td>
<td>0.96</td>
</tr>
</tbody>
</table>

* After Ogino (1980) for diet containing 40% crude protein.
methionine, threonine and valine of all the diets were lower than the required level. However, the levels of non-essential amino acids namely alanine, aspartic acid, glutamic acid, glycine, proline and serine were high in all the diets.

**Water stability of test diets and leaching loss of crude protein**

The stability of the experimental diets on immersion in water and the loss of crude protein by leaching were tested. The leaching loss of crude protein as percentage of original protein contained in diets are illustrated in figure 17.

Test diets TF, S\textsubscript{33} and WH\textsubscript{33} were more stable to handling and disturbance in water, than the rest of the diets. While diets S\textsubscript{66} and WH\textsubscript{66} floated on the surface of water on application, for about 5 to 10 minutes, others settled quickly to the bottom. The softening of the feed pellets was at a faster rate in diets having higher silage inclusion levels and slower in diets TF, S\textsubscript{33} and WH\textsubscript{33}.

In the experiment on the leaching loss of crude protein from test diets also, a similar trend was observed. The loss of crude protein from the diet TF was maximum which was at the rate of 13.06, 15.22 and 16.34\% at 5, 15 and 30 minutes after immersion in water (Figure 17). The loss of crude protein increased with time in all diets, but the loss was inversely proportional to the silage inclusion levels.

There was a sharp increase in the leaching of crude
Fig. 17. LEACHING LOSS OF CRUDE PROTEIN FROM THE TEST DIETS
protein from diets at the first 5 minute period, in the range of 8.32 to 13.06%. The rate of loss slowed down at the 15 minute mark, ranging from 11.12 to 16.34% and it continued at the same rate or slowed down slightly between the 15 and 30 minute time period. *Salvinia* silage diets were more stable than those of water hyacinth.

**DISCUSSION**

An ideal artificial feed should, to a large measure, tally with the natural food in its nutritional composition. A nutritive fish feed should have sufficient protein for growth, carbohydrates and fat for energy and vitamins and minerals for various metabolic activities. Huet (1972) suggested the following general proportions of diet components for a wide varieties of fish species, based on the fish feed mixtures of European manufacturers:

- **Rough protein**: 22.0 to 58.0%
- **Fats**: 1.2 to 8.0%
- **Carbohydrates**: 2.0 to 41.0%
- **Cellulose**: 1.0 to 6.0%
- **Minerals**: 10.4 to 22.0%
- **Water**: 6.5 to 11.0%
- **Vitamins**: Several

It could be noted from the results of the chemical analysis of the test diets (Table 15), that the percentage
composition of different components fall within the range suggested by Huet.

Due to reasons stated earlier, it was not possible to raise the crude protein level of the test diets beyond 26%, even though 33 to 38.5% has been suggested as the protein requirement in feeds for common carp (Nose, 1979; Viola et al., 1982), 30 to 35% for tilapia (Cruz and Laudencia, 1978; Mazid et al., 1979) and 25 to 40% for prawns (Rajyalakshmi et al., 1980).

About 50% of the total nitrogen of the diets was constituted by non-protein nitrogen. This indicates, to some extent, the proportion of hydrolysed protein to the whole protein. While Aoe et al. (1970), Nose et al. (1974) and Wood et al. (1985) have reported inferior growth rate of fish fed on diets having more than 60% non-protein nitrogen, Das (1958) has clearly demonstrated in a carp culture trial, that hydrolysed protein level of 50% gave a better growth response than diets containing complex proteins. So, it may be inferred that more than 60% of non-protein nitrogen in carp diets would result in inferior growth.

When compared to the levels of essential amino acid requirements of common carp suggested by Nose (1979) and Ogino (1980), all the seven test diets were not lacking in any of the amino acids, although lysine, methionine, threonine and valine values were lesser than the required level (2.1,
0.6, 1.3 and 1.2%, respectively). Therefore, fortification of the feeds with any of the amino acid was not made and it was felt that, for a farmer, it would be easier to mix the whole materials than adding a specific ingredient.

The ratio between protein and other nutrients in all formulated feeds, was in the range of 1:2.0 to 1:2.5. This again was in conformity with the findings of Mann (1961) who reported that while the ratio in natural fish food was upto 1:1.8, considerably wide ratios were encountered in artificial feeds.

The moisture content of 5 to 8% for pellet feeds cannot be considered high. Ether extract levels of 6 to 11% in test diets were comparable to the level (5 to 10%) suggested by Rajyalakshmi et al. (1980). Shell (1967) found better results with 7% corn oil added to the common carp diets.

Though crude fibre levels were high, they were well within the permissible level of 16% suggested by Perry (1975) excepting in diets S\textsubscript{50} and S\textsubscript{66} which contained 18.62 and 19.77%, respectively.

The 36 to 42% level of nitrogen-free extract of the diets was reasonable when compared to the 20% carbohydrate level suggested by Shell (1967) and 25-40% by Anderson et al. (1984). But Anderson et al. reported that no significant improvement could be observed in the growth when the pure
carbohydrate content was raised from 25 to 40% in their trial diets.

The ash content of 10 to 15% in the feeds was in agreement with the value suggested by Huet (1972). However, 5 to 10% ash content was suggested by many workers as suitable level in fish diets (Jackson et al., 1982; Anderson et al., 1984; Wood et al., 1985).

The gross energy level of 15-17 MJ/kg of diet could be considered quite adequate. Anderson et al. (1984) have used fish diets having energy values between 13 and 23 MJ/kg, to get good results.