

# Feed ingredients and fertilizers for farmed aquatic animals

Sources and composition



**Cover photographs:**

*Left top to bottom:* Feed ingredients (groundnut cake, rice bran and maize flour) for preparation of farm-made feed in a carp farm near Thanjavur district, Tamil Nadu, India (courtesy of P.E. Vijay Anand). Commonly used feed ingredients for preparation of farm-made aquafeed, Dhaka, Bangladesh (courtesy of FAO/Benoy Barman). Cooked maize used as feed for Chinese mitten crab, Suzhou city, Jiangsu province, China (courtesy of FAO/M. Weimin).

*Right top to bottom:* Harvest of striped catfish (*Pangasianodon hypophthalmus*) from a pond, Mymensingh, Bangladesh, 2009 (courtesy of FAO/Jayanta Saha). Pellet feed used for feeding of rainbow trout, Forel Farm, Wahdat, Tajikistan, 2009 (courtesy of FAO/Mohammad R. Hasan).

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by

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# Preparation of this document

This document was prepared as part of the FAO Aquaculture Management and Conservation Service's (FIMA) ongoing regular work programme on "Study and analysis of feed and nutrients (including fertilizers) for sustainable aquaculture development" programme entity "Monitoring, Management and Conservation of Resources for Aquaculture Development".

As part of the FIMA work programme, a targeted workshop on "Use of feeds and fertilizers for sustainable aquaculture development" was held in Wuxi, Jiangsu Province, China, on 18–21 March 2006. The workshop was organized by FIMA of FAO in collaboration with the Freshwater Fisheries Research Centre (FFRC) of China and the Network of Aquaculture Centres in Asia-Pacific (NACA). The working groups focused on the important role of farm-made aquafeeds in Asia and the need to develop and promote the use of farm-made feeds in sub-Saharan Africa, considered issues pertaining to the production and safe use of aquafeeds and deliberated on the constraints faced by industrial and small-scale aquafeed producers. Several key issues and constraints were identified, categorized and prioritized and appropriate actions were recommended. The workshop recommended FAO to undertake a number of actions to assist regional organizations and member country governments to address a number of identified issues and constraints pertaining to feeds and fertilizers for sustainable aquaculture development from a regional and global perspective. The full report of the workshop has been published in an FAO Fisheries Technical Paper "Study and analysis of feeds and fertilizers for sustainable aquaculture development" ([www.fao.org/docrep/011/a1444e/a1444e00.htm](http://www.fao.org/docrep/011/a1444e/a1444e00.htm)). One of the recommended actions was to compile synopses of the nutritional requirements of major cultured fish species and the feed ingredients currently used in compound/farm-made aquafeeds, including national/regional feed ingredient source books containing information on nutrient composition, quality control criteria, seasonal availability and market price. The present review has been undertaken as part of the above recommendation.

The manuscript was reviewed for linguistic quality and FAO house style by Mr Michael Martin. For consistency and conformity, scientific and English common names of fish species were used from FishBase ([www.fishbase.org/search.php](http://www.fishbase.org/search.php)).

We acknowledge Ms Tina Farmer and Ms Françoise Schatto for their assistance in quality control and FAO house style and Mr José Luis Castilla Civit for layout design. The publishing and distribution of the document were undertaken by FAO, Rome. Finally, Mr Jiansan Jia, Chief, Aquaculture Management and Conservation Service of the FAO Fisheries and Aquaculture Department, is acknowledged for providing necessary support to initiate the study and to complete the publication.

# Abstract

Farmed fish and crustaceans are no different from terrestrial livestock in that their nutritional well-being and health is based on the ingestion and digestion of food containing 40 or so essential dietary nutrients, including specific proteins and amino acids, lipids and fatty acids, carbohydrates and sugars, minerals, vitamins, energy, and water.

The present technical paper presents an up-to-date overview of the major feed ingredient sources and feed additives commonly used within industrially compounded aquafeeds, including feed ingredient sources commonly used within farm-made aquafeeds, and major fertilizers and manures used in aquaculture for live food production. Information is provided concerning the proximate and essential amino acid composition of common feed ingredient sources, as well as recommended quality criteria (when available) and relative nutritional merits and limitations (if any), together with a bibliography of published feeding studies for major feed ingredient sources by cultured species.

The technical paper is divided into five main sections. Section 1 deals with principles of feed ingredient and fertilizer analysis, including official methods of proximate chemical analysis, the analysis of amino acids, non-protein nitrogen, fatty acids, phospholipids, sterols, carbohydrates, sugars, energy, vitamins, minerals, the presence of anti-nutritional factors and contaminants, and the analysis of the physical properties of feed ingredients and feed microscopy. This is followed by a second section dealing with methods of analysis for fertilizers and manures, and a third section presenting a glossary of major feed and feed milling terms, including methods for ingredient classification and description in numerical terms.

The main body of the technical paper (section 4) deals with the nutritional composition and usage of major feed ingredient sources in compound aquafeeds, as well as the use of fertilizers and manures in aquaculture operations. Major feed ingredient and fertilizer groupings discussed include: animal protein sources (includes: fishery products, terrestrial livestock products, terrestrial invertebrate products), plant protein sources (includes: cereal products, oilseed products, pulse and grain legume seed products, miscellaneous plant protein sources), single cell protein sources (includes: algae, bacteria, yeast), lipid sources (includes: marine oils, livestock fats, vegetable oils), other plant ingredients (includes: terrestrial plant products, aquatic plant products), feed additives (includes: amino acids and related products, mineral products, vitamins, and chemical preservatives and antioxidants), and fertilizers and manures (includes: chemical fertilizers, organic manures). The feed ingredient section is followed by a summary of the major published studies dealing with potential feed and fertilizer contaminants, including metals and mineral salts, mycotoxins, persistent organic pollutants, Salmonellae and other microbes, veterinary drug residues, other agricultural chemicals and solvent residues, and transmissible spongiform encephalopathies.

The last section of the technical paper undertakes a comparative analysis of the essential amino acid profiles of the major reported feed ingredient sources for cultured finfish and crustaceans, and presents average reported dietary inclusion levels of major feed ingredient sources used within practical feeds, including their major attributes and limitations. Finally, the importance of feed safety, traceability, and use of good feed manufacturing practices is stressed, together with the importance of considering the long term sustainability of feed ingredient supplies and the need to maximize the use of locally available feed ingredient sources whenever economically possible.

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# Abbreviations and acronyms

|                               |  |
|-------------------------------|--|
| AOAC                          | Association of Analytical Communities (previously Association of Official Analytical Chemists; previously Association of Official Agricultural Chemists) |
| AAFCO                         | Association of American Feed Control Officials   |
| AV                            | Anisidine value  |
| B                             | Boron  |
| C                             | Carbon   |
| C                             | Chymotrypsin   |
| Ca                            | Calcium  |
| CF                            | Crude fibre  |
| CP                            | Crude protein  |
| Cu                            | Copper   |
| DDG                           | Distillers dried grains  |
| DDGS                          | Distillers dried grains with solubles  |
| DDS                           | Distillers dried solubles  |
| DHA                           | Docosahexaenoic acid   |
| DPL                           | Dried poultry litter   |
| DPW                           | Dried poultry waste  |
| DRW                           | Dried ruminant waste   |
| DSW                           | Dried swine waste  |
| E                             | Elastin  |
| EAA                           | Essential amino acid   |
| EE                            | Ether extract  |
| EFA                           | Essential fatty acids  |
| En                            | Endopeptidase  |
| EPA                           | Eicosapentaenoic acid  |
| FAC                           | Fat Analysis Committee   |
| FDA                           | US Food and Drug Administration  |
| Fe                            | Iron   |
| FFA                           | Free fatty acid  |
| GLC                           | Gas-liquid chromatography  |
| HPLC method                   | High-performance liquid chromatography method  |
| IFN                           | International feed number  |
| In                            | Insect Proteases   |
| K <sub>2</sub> O              | Potash   |
| lcPUFA                        | Long chain polyunsaturated fatty acids   |
| Mc                            | Microbial proteases  |
| Mg                            | Magnesium  |
| MIU                           | Moisture, impurities, unsaponifiables  |
| Mn                            | Manganese  |
| Mo                            | Molybdenum   |
| MUFA                          | Monounsaturated fatty acids  |
| N                             | Nitrogen   |
| NFE                           | Nitrogen-free extractives  |
| NPN                           | Non-protein nitrogen   |
| NRC                           | National Research Council  |
| P                             | Phosphorus   |
| P <sub>2</sub> O <sub>5</sub> | Phosphate  |

|       |   |
|-------|---|
| Pa    | Papain  |
| Pl    | Plasmin   |
| ppm   | parts per million                                   |
| Pr    | Pronase   |
| PUFA  | Polyunsaturated Fatty Acids                         |
| PV    | Peroxide Value                                      |
| S     | Subtilisin  |
| S     | Sulphur   |
| SCP   | Single Cell Protein                                 |
| SFA   | Saturated Fatty Acids                               |
| T     | Trypsin   |
| TBA   | Thiobarbituric acid number                          |
| TBARs | Thiobarbituric acid reactive compound concentration |
| Th    | Thrombin  |
| TVN   | Total volatile nitrogen                             |
| US\$  | US dollar   |
| Zn    | Zinc  |