Handbook on Ingredients for Aquaculture Feeds

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Kluwer Academic Publishers

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HANDBOOK ON INGREDIENTS FOR AQUACULTURE FEEDS

Only God knows everything,
Man cannot know everything,
But he can learn to know many things.

LIST OF ABBREVIATIONS

ANPU	=	Apparent net protein utilization
APD	=	Apparent protein digestibility
BV	=	Biological value
°C	=	Degree centigrade
CIC	=	Commonwealth of Independent Countries (former USSR)
CPHM	=	Cocoa-pod husk meal
CPM	=	California Pellet Mill
DDG	=	Distillers dried grains
DM	=	Dry matter
EAAI	=	Essential amino acid index
EC	=	European Community
EFA	=	Essential fatty acids
EU	=	European Union
FAA	=	Free amino acids
FCR	=	Feed conversion rate
FFA	=	Free fatty acids
FAO	=	Food and Agricultural Organisation of the United Nations, Rome/Italy
g	=	Gramme
GRAS	=	Generally recognized as safe
HFPC	=	Hydrolysed fish protein concentrate
HUFA	=	Highly unsaturated fatty acid
i.m.	=	Intra-muscular
IU	=	International unit
kcal	=	Kilocalorie
kg	=	Kilogramme
l	=	Litre
LTF	=	Low thermal fish meal
mcg	=	Microgramme
mg	=	Milligramme
MJ	=	Megajoule
mm^3	=	Millilitre
MT	=	Metric tonne
NPU	=	Net protein utilisation
NRC	=	National Research Council (U.S.A.)
PER	=	Protein efficiency ratio
ppb	=	Parts per billion
ppm	=	Parts per million

ppt	=	Parts per trillion
PUFA	=	Polyunsaturated fatty acid
RNA	=	Ribonucleic acid
SGR	=	Specific growth rate
UBE	=	Used bleaching earth
UGF	=	Unidentified growth factors
WHO	=	World Health Organisation of the United Nations, Geneva/Switzerland

PREFACE

Current growth in global aquaculture is paralleled by an equally significant increase in companies involved in aquafeed manufacture. Latest information has identified over 1,200 such companies, not including those organizations in production of a variety of other materials, i.e., vitamins, minerals, and therapeutics, all used in varying degrees in proper feed formulation. Aquaculture industries raising particular economically valued species, i.e., penaeid shrimps and salmonids, are making major demands on feed ingredients, while relatively new industries, such as tilapia farming, portent a significant acceleration in demand for properly formulated aquafeeds by the end of the present decade and into the next century.

As requirements for aquafeeds increases, shortages are anticipated in various ingredients, especially widely used proteinaceous resources such as fish meal. A variety of other proteinaceous commodities are being considered as partial or complete replacement for fish meal, especially use of plant protein sources such as soybean meal. In the past five years, vegetable protein meal production has increased 10% while fish meal production has dropped over 50%, since 1989, largely attributed to overfishing and serious decline in wild stock. Throughout fisheries processing industries, traditional concepts as "waste" have given way to more prudent approaches, emphasizing total by-product recovery. Feed costs are a major consideration in aquaculture where in some groups, i.e., salmonids, high protein-containing feeds using quality fish meal, can account for as much as 40 to 60% of production costs. About 67% of the actual feed cost can be attributed to the fish meal protein fraction. Clearly, this is an untenable situation as global aquaculture increases in size and diversity of commercial species. Considerations such as cost and availability of commonly utilized aquafeed ingredients also must be recognized as new formulation practices develop. In all likelihood, these will differ from conventional procedures with movement in usage of non-traditional feed ingredients. Currently, aquafeed least-cost formulations mainly are geared to those traditional procedures used in livestock feeding and not designed especially to meet the needs of rapidly growing aquaculture industry.

Innovative approaches must explore the wide variety of processing by-products potentially available as nutritionally valuable ingredients in specific aquafeeds. This must be correlated with the availability of such ingredients, especially plant and animal proteins, in individual countries and the dictates of economic pressures. Competing feedstock (ingredient) demand by major livestock industries is another factor in proper allocation of feed ingredients. Regardless, the final processed aquafeed must meet specific physical standards, such as water stability and palatability, as well as satisfying the nutritional needs of the aquatic species being cultivated. Ultimately, diet selection and use of alternative proteins will relate to the intensity of the cultivation practice. While high cost "nutrient dense" complete pelleted diets may be feasible in intensive

operations, greater flexibility is possible in terms of ingredient substitution in less extensive operations where natural feeding processes may occur.

As new non-traditional diets are formulated, many using the various ingredients enumerated in this book, studies will be needed to ascertain their digestibility and composite nutritional value of the formulation to the particular targeted species. Ancillary attention also must be given to palatability of the diet and its effectiveness in achieving an economically sound conversion rate. Of paramount importance is the effect of individual ingredients on the physical stability of the final pellet and its compostie texture, facilitating optimal ingestion. For instance, shrimp feeds need both good water stability and rehydration properties which directly affect texture and optimal ingestion. Similarly, hard inflexible small dietary particles for first-feeding stages of fish may be rejected. Finally, the effect of a particular ingredient on final sensory properties of the aquatic species must be given consideration to insure maximum consumer acceptability of the processed product. For instance, excessive dietary levels of corn gluten meal and alfalfa meal impart an undesirable yellowish color to catfish flesh due to concentrations of xanthophylls, especially high in corn gluten meals. Conversely, with shrimp, especially such commercial species as *Penaeus monodon* and *Penaeus japonicus*, inclusion of ingredients (i.e., shrimp meal) rich in carotenoids (especially astaxanthin), is needed to impart proper pigmentation to the crustacean exoskeleton.

The efforts of the authors to make available a thorough compilation of feed ingredients, together with relevant performance data where possible, is a worthwhile contribution to global aquaculture. Paradoxically, major anticipated growth in aquaculture is projected to occur in those countries where traditional feed ingredients are lacking or totally unavailable. Thus the information contained here has truly practical value, and unquestionably will be utilized by aquaculturists. Various of the ingredients listed, i.e., soybean meal, fish meal, crab meal, shrimp meal, and other animal and plant by-products already have acceptance in various degree in aquaculture feeds. What is needed are new formulations that reflect reductions in feed costs and especially more prudent use of available commodities. Nowhere else has such a compilation of relevant ingredient data been attempted, and the authors are to be commended for their initial efforts. Certainly, the database will be significantly expanded as experimental results indicate nutritional value and dietary feasibility of the various ingredients presented. Others will be added as food processing industries endeavor to recover by products that have real economic value, rather than that of a waste product to be discarded.

Newly developed ingredients for aquafeeds are appearing in the international marketplace. One example is that of the carotenoid (astaxanthin) containing yeast *Phaffia rhodozyma*, currently being used as an effective pigmenting agent in salmonid and other aquatic diets. Technological developments are being explored to enhance usage of plant and animal feedstuffs in aquafeeds. Examples include, among others, such approaches as development of genetically engineered soybean with increased levels of the essential amino acids methionine and lysine, as well as possible removal of bone from meat and bone meal, thereby reducing calcium levels with a concurrent increase in the protein content. Hydrolyzed protein products, including fish protein concentrates from by-catch and processing water are being commercialized along with hydrolyzed proteins from blood, egg, poultry and liver products.

The stated objectives of this book, "to contribute to a better understanding of commonly used aquaculture feed ingredients and to find some useful information on some potential feedstuffs for aquaculture diets", clearly are valid ones in terms of needs of present day aquaculture. Hopefully, this worthwhile endeavor will serve as a catalyst for further compilation and ultimate critical analysis of basic and applied information on a wide range of specific ingredients for use in commercial aquaculture.

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