Nutrient Requirements of Warmwater Fishes (1977)

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OF
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NATIONAL ACADEMY OF SCIENCES
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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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PREFACE

The publication of *Nutrient Requirements of Trout, Salmon, and Catfish* (NRC, 1973) demonstrated the need for a similar publication on the nutrient requirements of warmwater fishes. The tremendous increase in warmwater fish production in the United States and the world since 1950 justifies the need for consolidation of information on the nutrition of these animals.

The Subcommittee on Warmwater Fish Nutrition prepared this report from published information on a limited number of warmwater fish species for which nutritional requirements are known or partially known. The Subcommittee feels that these data may also be applicable to dietary formulation for other, similar warmwater fish species for which there is no available nutritional information. In this way, this bulletin may serve as a guide to better nutrition for the many warmwater fishes.

The Subcommittee is indebted to Damon C. Shelton of the Ralston Purina Company and to John E. Halver of the U.S. Fish and Wildlife Service for their comprehensive reviews and constructive comments on the manuscript.

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INTRODUCTION

Need for research in warmwater fish nutrition and diet development was not considered important until the early 1950s. Large amounts of land and low-cost labor were available, and acceptable levels of fish production were obtainable from native pond organisms. Need for higher production levels accelerated after 1960 because of rising land and labor costs, as well as increased demand of fish for food and recreation. Thus, fish husbandry changed from the type in which the animal obtained all its food from the aquatic environment to that in which those factors were supplied from external sources by the fish culturist.

In this report, warmwater fishes are those freshwater and marine species that are raised for food, sport, or ornamental purposes and that have optimal growing temperatures above 18° C. Species for which a significant amount of nutritional research data are available include channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and eel (*Anguilla* sp.). Other commercially important cultured fishes but with limited nutritional research data available are tilapias (*Tilapia* sp.), yellow tail (*Seriola quinquerodiata*), sea bream (*Abramis* sp.), milkfish (*Chanos chanos*), ayu fish (*Plecoglossus altivelis*), Chinese carps, marine and freshwater prawns, bait fishes, sport fishes, and ornamental fishes.

Requirements for some nutrients are similar for most fish species, but environmental differences and natural foods occurring in some cultural systems may affect the apparent nutrient need. Specific examples of these effects are too detailed for discussion at this point, and the reader is referred to the bibliography.

This publication is concerned with the basic nutrients, the requirements, and the deficiency signs and can be used as a guide in formulation and manufacture of warmwater fish diets. References are made to digestibility and cultural practices as these relate to the nutrition of these fishes. Tables of feedstuff composition and typical warmwater fish diets are included.

ENERGY AND METABOLISM IN WARMWATER FISHES

Fish require energy for growth, activity, and reproduction. This energy is derived from oxidation of food. The biological process of utilizing energy is defined as metabolism. The rate at which energy utilization occurs is called metabolic rate. Metabolic rate in fishes is influenced by temperature, species, age or body size, activity, physical condition, starvation, and seasonal or diurnal fluctuations of body functions. Oxygen or carbon dioxide concentration, pH, and salinity of the water are also responsible for metabolic rate alterations in fishes.

Fishes utilize dietary components differently from certain other animals. Certain fishes utilize proteins and fats rather than carbohydrates as primary energy sources. Therefore, the conversion of gross energy values of food to energy values available to fishes are different from those used for warm-blooded animals.

METABOLIC RATE

The metabolic rate of any animal is expressed as heat produced or oxygen consumed per unit body weight per unit time.

The basal metabolic rate (sometimes given as BMR or the minimum metabolic rate) of any animal is the oxygen consumed per unit time while the animal is at rest. The BMR of fishes may be defined in the same way. However, water conditions must be defined and the resting state of fishes is difficult to describe. Therefore, the term Standard Metabolic Rate (SMR) is used for fishes and a Standard Environmental Temperature (SET) for each species should be established. SET for catfish has been given at 30° C. SET for carp has been suggested as 25° C and European eels as 22° C.

The use of an SET for each warmwater fish species has a direct advantage to the researcher and the fish nutritionist. The metabolic rate of a particular fish species can be determined at a water temperature within limits of normal habitation for that fish and corrected to the metabolic rate at SET. More useful comparisons can then be made between fish species as well as between research results reported on the same fish species by various research personnel throughout the world.

Data are available relating metabolic rate of many fish species to water temperature. Each fish species observed showed a definite correlation between oxygen consumed and environmental temperature. However, the correlation is not a linear function. Metabolic rate is depressed to a greater relative degree at lower water temperatures and advanced at a greater relative degree at the higher temperatures. Research data plotted graphically have shown a "normal curve" effect for all species studied to date. The shape of the curve is similar for all species but skewed to the right or left along the baseline, depending on the preferred temperature of the fish species being studied (Figure 1). Metabolic rate-water temperature relationships can also be expressed mathematically to relate data taken at temperatures other than SET to the metabolic rate at SET for that fish species. The use of the temperature coefficient (Q_{10}) is suggested where $K_2 = K_1 \times Q_{10}(t_2 - t_1) \div 10$. Values for Q_{10} at temperature (°C) intervals are given as follows:

Q_{10}	0-5°	5-10°	10-15°	15-20°	20-25°	25-30°
	10.9	3.5	2.9	2.5	2.3	2.2

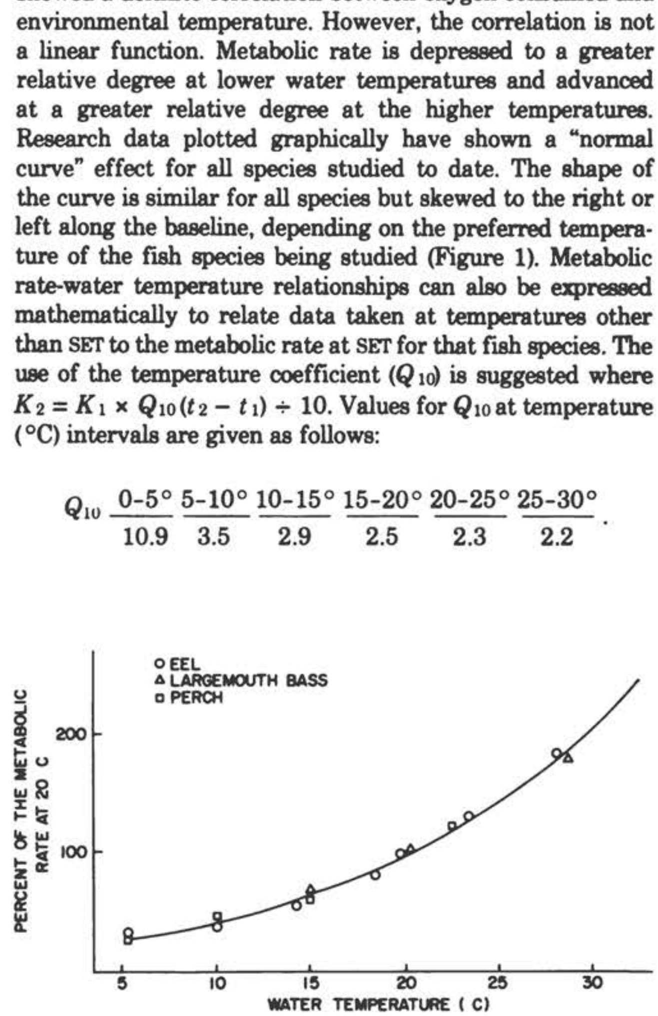

FIGURE 1 Relationship of metabolic rate of three warmwater fish species to environmental temperature. Adapted from Winberg, 1956.

This equation also makes possible comparisons between measurements of metabolic rate made at different temperatures by adjusting all figures for metabolic rate to SET or any other chosen temperature. The equation also provides a method for calculating energy requirements at any given water temperature.

RELATIONSHIP OF METABOLIC RATE TO ENVIRONMENTAL VARIABLES

Water temperature is an environmental variable that has a major effect on metabolic rate of fishes because body temperature of most fishes at rest will be near the environmental temperature. Alteration of environmental temperature produces an alteration in the reaction rate of all physiological and biochemical processes within the fish. Metabolic energy requirements increase with rising water temperatures and decrease when water temperatures are reduced.

Metabolic rate per unit weight decreases in all fish species as body size increases. There is a direct parabolic correlation between body surface of the fish and metabolism. This is expressed by the equation $T = \alpha W^r$, where T = total metabolism measured by the amount of oxygen consumed per hour, α = level of metabolism, W = weight of the fish in grams, and r = the weight exponent. Substituting values for α and r into this equation becomes $T = 0.297\ W^{0.81}$ for many of the warmwater fishes. The metabolic rate of most warmwater fish species can be calculated if the body weight is known. As an example, the rate of metabolism at 15 °C for a 12-g carp is 24.48 kcal/kg of body weight/day, and a 600-g carp requires but 7.97 kcal/kg of body weight/day.

Activity of the fish alters metabolic rate. The relationship between the resting metabolic rate and the metabolic rate with activity at the same temperature has been designated the "activity coefficent" (Figure 2).

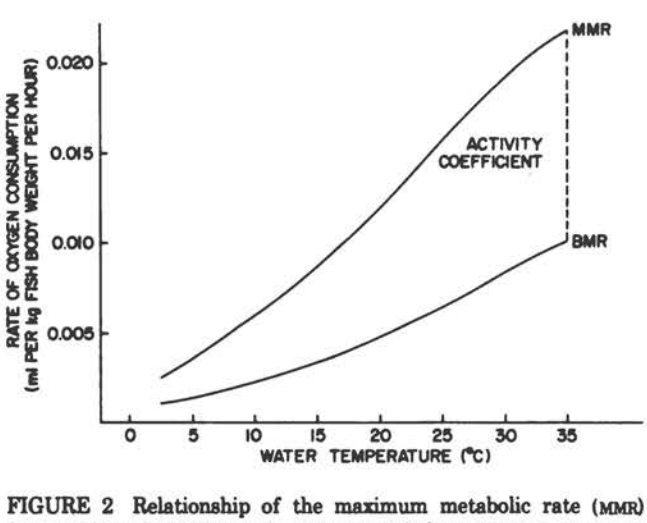

FIGURE 2 Relationship of the maximum metabolic rate (MMR) from sustained activity and resting metabolism (BMR) to temperature in the bullhead (*Ameirus nebulosus*). From Winberg, 1956.

The oxygen concentration in environmental water influences metabolic rate in fishes. The rate of oxygen consumption will remain constant as long as the oxygen content of the water is consistently high enough for maintenance of a particular metabolic rate. If the dissolved oxygen falls below a certain level, the metabolic rate is reduced and activity is suppressed. Metabolic rate of the fish will continue to be suppressed to a greater and greater degree as environmental oxygen is reduced until it falls below a threshold value necessary to support life. The level of dissolved oxygen that affects metabolic rate at a given environmental temperature is designated as the "critical point." The critical point varies with each fish species.

A high level of dissolved carbon dioxide in environmental water reduced the metabolic rate of fishes. This metabolic rate reduction remains as long as the high carbon dioxide concentration is present.

Rapid change in pH and environmental salinity cause an immediate change in metabolic rate. These metabolic rate changes soon stabilize under the new environmental conditions and the oxygen consumption returns to near the prestress level.

Certain fish species show diurnal oxygen consumption fluctuations that are probably related to instinctive feeding habits of the fish. Seasonal fluctuations and metabolic rate have not received much attention, yet they must be considered when establishing an SMR for any fish species. Much of the seasonal variation probably occurs as the result of behavior and reproductive status of the fish.

Physical condition of the fish may affect metabolic rate. A fish that does not exercise may have a metabolic rate higher than a fish in excellent physical condition.

Oxygen consumption of most fishes increases immediately after food is assimilated into the body. The increased metabolic rate continues until a post-absorptive state is attained.

Starvation or reduced feeding level decreases metabolic rate. Sexual maturation, reproduction, or feeding activity have no lasting effect on metabolic rate other than would be expected from increased activity during these periods.

RELATIONSHIP OF FISH BODY TEMPERATURE TO WATER TEMPERATURE

The body temperature of a resting fish is usually maintained at or near the environmental water temperature. Activity of the fish produces heat that is lost to the environment. The rate of heat loss is related to body surface of the fish and water temperature. Body surface in square decimeters can be estimated by the equation: Body surface = Body wt in $g^{0.67} \div 10$. The energy requirements necessary for all metabolic functions can be calculated, depending on fish species. As an example, carp utilize 25 cal/dec^2/h at 15° C. Approximately 70 percent of these total calories is used for maintenance energy and growth, and the remaining 30 percent is lost as heat to the environment. The rate of heat loss can be calculated if the body weight of the fish is known.

ENERGY NEEDS FOR MAINTENANCE AND GROWTH

Energy for Maintenance

Energy is needed in all animals. The work performed is either mechanical work (muscular activity), chemical work (biochemical function), electrical work (nerve impulses), or osmotic work (maintenance of biological salt balance—especially significant in fish). All work requires expenditure of energy for either heat (ΔH) or free energy (ΔF). Heat energy is used to maintain body temperature, which is not important to fishes. Free energy must be available for biological activity and growth. Heat energy and free energy together constitute the biological gross energy that must be supplied by the diet.

Energy for Growth

Available free energy is necessary for growth. Growth in fishes also depends on suitable environmental temperature, living space, water flow, water quality, and other factors. In general, all needs for body function must be met before free energy will be available for growth.

Only limited data are available on caloric requirements for growth of the many cultured warmwater fish species. However, protein level and source should be balanced to digestible energy levels to obtain the maximum conversion of food to growth.

DIETARY COMPONENTS AND DIGESTIBLE ENERGY

Rations that will support the body needs of fishes must contain proteins, lipids, carbohydrates, and nonenergy components. The three major components should be balanced to the energy, physiological, and biochemical requirements of each fish species. Much of the research to set dietary energy requirements for the various fish species has been done on trout and salmon, which are carnivorous, cold-water (optimum growing temperature below 18° C) fishes. Only cursory research has been done on herbivorous fishes.

Digestible Energy

Digestible energy is that energy absorbed from the diet. It is measured by calculating energy difference between dietary intake and fecal energy. Digestible energy from the major dietary components (protein, fat, and carbohydrate) can be calculated from digestibility coefficients. Average values were calculated for channel catfish at 3.5 kcal/g of protein, 8.1 kcal/g of fat, and 2.5 kcal/g of crude carbohydrate. Herbivorous or omnivorous fishes may utilize these components differently. Information on apparent digestible energy from various dietary components for channel catfish is given in Table 1. Nonenergy components in the diet of fishes include the vitamins, minerals, nondigestible components, food contaminants, and others. The energy derived from such

TABLE 1 Energy Digestion Coefficients and Digestible Energy of Feeds for Channel Catfish Compared to Swine

Feed	International Feed No.	Gross Energy[a] (kcal/kg)	Digestion Coefficients: Channel Catfish[b] (%)	Digestion Coefficients: Swine[c] (%)	Digestible Energy: Channel Catfish[b] (kcal/kg)	Digestible Energy: Swine[c] (kcal/kg)
Animal by-products						
Poultry, feathers, hydrolyzed meal	5-03-795	5125	66.6	53.2	3414	2728
Fish, meal mech extd	5-01-977	4622	84.5	70.0	3906	3235
Meat, w bone, meal rendered	5-00-388	4310	80.5	48.7	3470	2100
Oilseed meals						
Cotton, seeds, meal solv extd	5-01-619	4549	56.2	63.9	2557	2910
Soybean, seeds, meal solv extd	4-05-199	4568	56.4	84.5	2576	3862
Cereals and by-products						
Corn, dent yellow, grain	4-02-935	4228	26.1	95.9	1104	4056
Corn, dent yellow, grain, boiled dehy	4-02-853	4323	58.5	—	2529	—
Wheat, grain	4-05-211	4229	60.4	87.1	2554	3682
Wheat, bran	4-05-190	4420	56.2	63.8	2484	2821
Fibrous foods						
Alfalfa, meal dehy	1-00-025	4246	15.7	36.3	667	1543
Food mixture						
Fish, meal mech extd 15%	5-01-977					
Soybean, seeds, meal solv extd 40%	5-04-604					
Wheat, bran 45%	4-05-190	4428	67.8	—	3002	—

[a] As-fed basis.
[b] Cruz (1975).
[c] National Research Council (1973).

components is negligible and is usually not considered as contributing calories to the diet.

DIETARY EFFICIENCY

The term dietary efficiency is used to designate the practical conversion of food to fish tissue. This is one of the primary criteria for evaluating a diet. One objective of the fish nutritionist is to formulate a diet that will yield the highest possible conversion to fish growth and continue to maintain health and well-being in the fish. Naturally occurring foods of many of the cultured warmwater fishes (basses, sunfishes, perches, pikes, and others) generally are utilized more efficiently than are diets prepared from feedstuff components used by the fish food industry.

Dietary efficiency can be calculated if certain information is known about the fish species being considered. (Twenty-five cal/dec^2 of body surface/h has previously been stated as the caloric requirement for carp at 15° C. A 100-g carp has a surface area of $100^{2/3} \div 10 = 2.154$ dec^2. The gross caloric needs per day are 25 cal/h $\times$ 24 $\div$ 1,000 = 0.6 kcal/day. The daily caloric needs for a 100-g growing carp becomes 2.154 dec^2 $\times$ 0.6 kcal/day = 1.29 kcal, or 1,292 kcal/100 kg of fish/day.) An efficient diet must contain 1,292 kcal of ME/kg and be fed at a feeding level of one kg diet/100 kg of fish/day to supply the caloric needs. Dietary efficiency for other fish species at different water temperatures may be determined by the same method.

The quality of a diet as it relates to dietary efficiency is of great importance. The ingredients that go into the formulation of the diet must be related to the physiological needs of the particular fish being fed. Diet formulas for carnivorous fishes are different from diet formulas for herbivorous or omnivorous fishes. Therefore, the fish nutritionist must design efficient diets for the particular fish being fed.

Energy Requirements

Energy recommendations for channel catfish and carp have been derived primarily from practical experimentation by feeding diets that varied in caloric value. The diet that yielded the best growth was assumed to have the most satisfactory caloric level for the fish being fed. Only cursory research of this nature has been done with other warmwater fish species.

Metabolizable Energy Requirements

Metabolizable energy (ME) needs of a fish may be determined from the body surface, water temperature, fish species, and dietary efficiency as discussed previously. Energy requirements for catfish using ME values for poultry have been estimated to be between 1,650 and 2,500 kcal/kg of food, depending on protein content of the diet (Figure 3). However, the few ME values determined specifically for catfish have been found to be lower than those given for poultry. Therefore, the values given above are not absolute.

Fish culturists use another concept for estimating gross energy requirements. This concept is the "conversion" concept in which the metabolizable calories required to produce a kilogram of fish tissue are determined. Fish culturists are in general agreement that a feed-to-fish growth conversion of 1.7 or less suggests that the diet is adequate in energy. This is because energy for biological maintenance and other vital needs of fishes will be supplied before energy is available for growth.

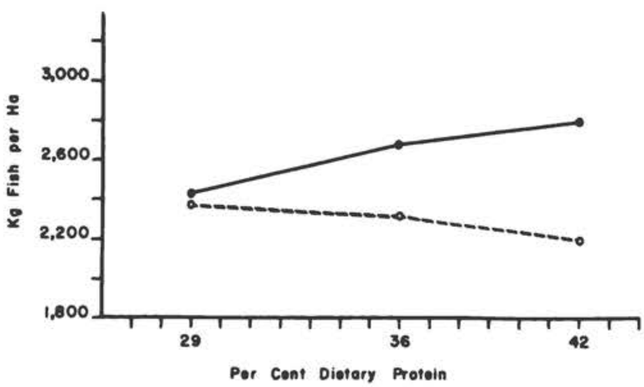

FIGURE 3 Yield of channel catfish from diet containing three percentages of protein at high (●—●) and low (○···○) energy levels in ponds. Energy levels were 2,600 and 2,000 kcal/kg calculated as digestible energy for catfish, or 2,860 and 2,200 kcal/kg calculated as metabolizable energy for poultry (SOURCE: Prather and Lovell, 1973).

DIGESTION AND ABSORPTION OF FEEDSTUFFS

The nutritional value of a diet is determined ultimately by the ability of the fish to digest and absorb it. Digestion depends upon both the physical and chemical characteristics of the food and the kind and quantity of digestive enzymes in the gastrointestinal tract. There are species differences in digestive systems among fish. Some fishes have an acidic stomach; others, such as the carp, lack the acidic phase of digestion due to the absence of a true stomach.

Some fish have pharyngeal teeth or gizzards for grinding. Length of the digestive tract varies from ½ to ⅔ the body length for carnivorous fishes to 5 to 6 times the body length for herbivorous types. Various factors have also been shown to affect the rate of digestion. Water chemistry and temperature, type of diet, size and age of the fish, prior nutritional status, frequency of feeding, and other factors affect digestion. Since food is not useful to the organism until it is digested and absorbed, the decision to include a certain ingredient in the diet, for purposes other than bulk, should be based on the ability of the fish to digest and absorb it under the particular cultural conditions.

Many studies have been conducted to determine the enzymes present in the digestive tract of various fishes. These studies point out the presence of general digestive enzyme systems similar to those found in higher animals.

Limited studies have been made on the digestibility of specific dietary ingredients by various fish species. These studies are important because the physical condition of the dietary ingredients or the method by which they are processed often influences digestibility.

DIGESTIVE ENZYMES

The overall process of digestion in fish is essentially the same as that of other animals, with the exception of stomachless fishes. The major sources of the digestive enzymes are the stomach, intestinal mucosa, pancreas, and the pyloric caeca.

The general system of protein digestion found in most animals occurs in all fishes examined, except the stomachless fishes. Protein digestion is initiated in the stomach. Pepsinogen and hydrochloric acid are secreted by those fishes with a stomach. Pepsinogen is converted to active pepsin under the influence of hydrochloric acid. Most fish pepsins have reaction maxima ranging from pH 1.5 to 2.5. The digestive hormone gastrin has been demonstrated in at least one fish species. This hormone is essential for initiation of hydrochloric acid secretion. Exceptions to normal stomach digestion occur in those fishes having no true stomach. The entire digestive process takes place in the alkaline environment of the intestine in these fishes.

Intestinal and caecal proteolytic enzymes of fishes include trypsins, chymotrypsins, carboxypeptidases, aminopeptidases, tripeptidases, and dipeptidases. Primary secretions of trypsinogen and chymotrypsinogen are products of the pancreas. Trypsinogen is converted to the active enzyme through the influence of enterokinase, the latter having deen demonstrated in several fish species. Chymotrypsinogen is altered to chymotrypsin through activity of trypsin.

Fat is digested by the enzyme lipase into fatty acids and glycerol. These digestive products are absorbed after digestion. However, certain fishes absorb finely emulsified fats directly into the cells of the gastrointestinal tract, where intracellular digestion takes place. Certain fishes have lipase in the stomach. Digestion and fatty acid absorption occur to a minor degree in this organ. Most fishes split fats in the caecal and intestinal area of the gastrointestinal tract and digestive products are absorbed by these regions. No lacteals (intestinal lymphatic ducts) have been demonstrated in fish, and digested fats move into the epithelial lining of the gastrointestinal tract where these are gradually utilized.

Esterase splits certain lipid compounds such as phospholipids, cholesterol, waxes, and others. Esterase has been reported in the stomach, pyloric caeca, and intestine of certain fishes.

All fishes secrete bile. Bile alkalizes the acid stomach contents. Because of its role in emulsification of fats, it is essential for normal lipid digestion and absorption. Reabsorption of bile salts assists in maintenance of digestion and subsequent health of all fishes.

Digested food is absorbed by fish in three major ways. Much of the digestion products are absorbed by simple

TABLE 2 Protein Digestibility by Ruminant, Swine, Rabbit, and Carp[a]

Plant	International Feed No.	Digestion Coefficients			
		Ruminant (%)	Swine (%)	Rabbit (%)	Carp (%)
Wheat, grain	4-05-211	91	—	—	83
Barley, grain	4-00-549	77	70	33	64
Rye, grain	4-04-047	83	—	—	63
Oat, grain	4-03-309	83	49	64	64
Corn, dent yellow, grain	4-02-935	80	70	25	66
Peas, seeds	5-03-600	88	81	64	79
Soybean, seeds, heat processed	5-04-597	80	80	74	81
Lupine, sweet yellow, seeds	5-08-458	92	90	—	85

[a] SOURCE: Nehring (1965).

diffusion, some by active transport, and some particles are absorbed by phagocytosis.

FACTORS AFFECTING DIGESTION

The digestive system is incomplete in newly hatched fishes. Differentiation of the digestive organs proceeds during early life stages. The function of these organs is established while the yolk material in the newly hatched fish is being absorbed. The relative activity of the digestive enzymes is related to the differentiation of these organs, and activity increases after feeding begins.

The activity of digestive enzymes has been shown to vary with changes in diet composition. Relatively high proteolytic activity was found in the intestine of young carp and tilapia after the administration of high-protein diets. Various carbohydrases were found to exhibit increased activity in carp intestine within 1 week after being fed diets high in starch.

Biological functions in fishes are temperature-dependent, and the rate of digestion varies with water temperature. However, digestibility of protein remains relatively constant within a range of water temperature adequate for growth but decreases with a decline in water temperature below this range (Figure 4).

The rate of digestion also varies with species of fish. Passage of food was found to be faster for panfishes than for larger game fishes. The panfishes digested about 50 percent of the stomach volume in 5 hours at water temperatures between 18° and 23° C, 75 percent in 12 hours, and nearly 100 percent in 21 hours. Feeds of animal origin were digested more rapidly than plant material, and the digestive rates for the same kinds of foods were similar for different sizes of panfish. Northern pike required about 20 hours for 50 percent reduction of stomach contents and 50 hours for 100 percent. Digestive rates for walleye and largemouth bass were intermediate between pike and panfishes. Studies with the white amur indicated that the food passes through the digestive tract in less than 8 hours at 30° C with about 50 percent of the natural food material passing out as feces.

DIGESTION AND ABSORPTION

Digestibility values have been reported on protein, carbohydrates, and fats for several feedstuffs in various species of fish and are summarized in Tables 12, 13, and 14. Processing of diet ingredients may alter digestibility, such as the use of excessive heat, resulting in passage of the ingredient unchanged through the digestive tract of the fish.

Dietary protein is generally digested and absorbed in a similar manner by fish, regardless of their variation in food habits and digestive organs. Refined proteins, such as casein, as well as raw fish meat and fish protein concentrates, are almost completely digested. Fish meals and properly processed oil seed meals are well digested by most of the fish studied. Meat and poultry by-products have slightly lower protein digestibility than fish meals for channel catfish. Carp can digest the proteins of plants as well as or slightly better than monogastric mammals, but less than ruminants (Table 2).

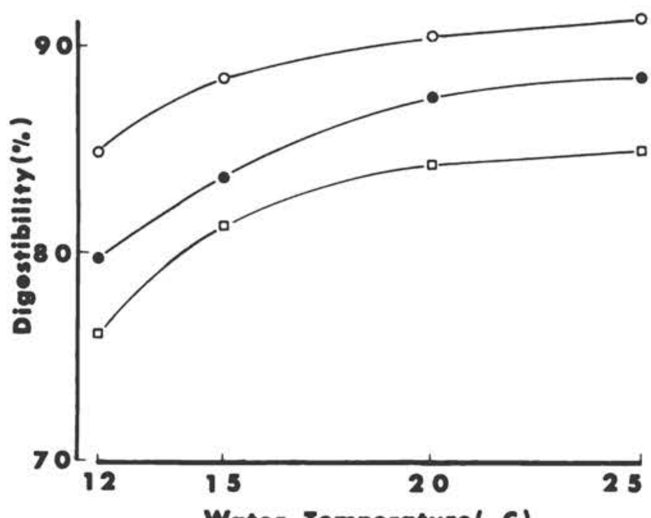

FIGURE 4 The relationship between protein digestibility and environmental water temperatures in carp. ○, Commercially formulated trout diet; ●, torula yeast diet A; □, torula yeast diet B (SOURCE: Nose, Yada, and Abe, 1974).

In most fishes studied, other nutrients have an effect on protein digestibility. In yellowtail and channel catfish, protein digestibility in dry diets containing fish meal is lower when the diet contains a high percentage of carbohydrate. High amounts of roughage reduce the digestibility of protein in most fishes.

Generally, carbohydrate digestibility increases as the carbohydrate levels in diets decrease. This relationship is less noticeable in carp. The digestibility of carbohydrate decreases with complexity of the molecular structure. Glucose and maltose produce higher blood glucose levels in catfish than dextrin or starch. Cooked starch is more digestible than raw starch.

Digestibility of fats is affected generally by melting points and fatty acid composition. Experiments on carp show higher digestibility of pollack liver oil and soybean oil than lard. Coconut oil, which is composed mainly of short-chain fatty acids, is absorbed at about the same rate as soybean oil, although the melting point of coconut oil is much higher than that of soybean oil. Lipids in most practical feedstuffs are highly digestible by channel catfish (Table 14).

PROTEINS AND AMINO ACIDS

Protein is a major constituent of the animal body, and a liberal and continuous supply is needed throughout life. The primary aim of fish culture is to transform dietary protein into tissue protein efficiently.

PROTEIN REQUIREMENTS

Natural diets of fish are rich in protein. Generally, fish require a higher percentage of protein in the diet than birds and mammals. This may be because fishes utilize carbohydrates less efficiently. Therefore, some dietary protein may be metabolized for energy.

The amount of dietary protein required by fishes is directly influenced by the indispensible amino acid pattern in the diet. The minimum amount of protein needed to produce maximum growth has been investigated with purified test diets in several species of warmwater fishes (Table 3).

The amount of protein that should be provided in practical diets depends largely upon digestibility and amino acid composition. Nonprotein energy of the ration and the quantity of diet consumed by fish also affects the percent of protein that must be present in the diet. There are so many variables that affect optimum protein percentage in fish rations that there is difficulty recommending an appropriate protein level for each species of fish at various environmental conditions. However, the ranges of protein level found in practical diets are summarized for channel catfish, eel, carp, ayu fish, and red sea bream in Table 4. Larger amounts of protein are incorporated in diets for eel, ayu fish, red sea bream, and prawn than for carp and catfish. Prawn require a relatively high amount of protein in the diet. Rations containing 54 percent and 64 percent protein produced higher growth rates and feed efficiencies than a diet containing 44 percent protein (Figure 5). The data given in Figure 5 are calculated results using the following formulae:

TABLE 4 Recommended Protein Levels in Percent of Practical Fish Diets (As-Fed Basis)

Species	Fry to Fingerlings	Fingerlings to Subadults	Adults and Brood Fish
Channel catfish	35-40	25-36	28-32
Eel	50-56	45-50	—
Carp	43-47	37-42	28-32
Ayu fish	44-51	45-48	—
Red sea bream	45-54	43-48	—

TABLE 3 Protein Requirement of Warmwater Fishes

Species of Fish	Protein Used in Test Diet	Water Temperature (°C)	Crude Protein Level in Diet for Maximum Growth (%)
Carp	Casein	23.0	38.0
Eel	Casein + Arg + Cys	25.0	44.5
Channel catfish	Casein	24.4	35.0
	Whole egg protein	26.7	36.0[a]
			24.0[b]
Red sea bream	Casein + Gelatin	25.0	55.0

[a]3,410 kcal/kg of diet.
[b]2,750 kcal/kg of diet.

$$\text{Daily growth rate (\%): } a = \left(t\,\frac{W}{W_0} - 1 \right) \times 100$$

$$\text{Feed efficiency (\%): } e = \frac{(W + D) - W_0}{F} \times 100$$

where W_0 is initial body weight average in grams, W is final body weight average in grams, t is duration of rearing experiment in days, F is total amount of feed intake in grams, and D is total body weight of dead prawns in grams. These mathematical representations make feed efficiencies of greater than 100 percent possible.

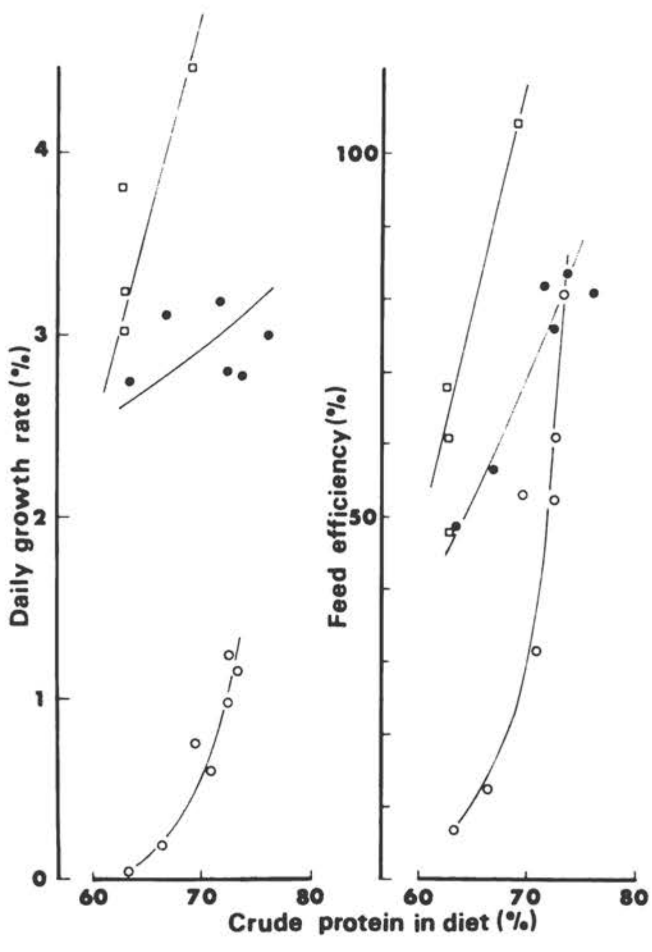

FIGURE 5 The relationship between crude protein content of diets and daily growth rate or food efficiency of the prawn *Penaeus japonicus*. ○, Experimental period 30 days, initial average body weight 7.2 g; ●, Experimental period 50 days, initial average body weight 1.7 g; □, Experimental period 25 days, initial average body weight 1.0 g. SOURCE: Deshimaru and Shigeno, 1972.

AMINO ACID REQUIREMENTS

Ten amino acids have been identified as indispensible for growth of catfish, carp, red sea bream, two species of eel, and two species of prawns (Figures 6 and 7). Diets deficient in any of the indispensible amino acids result in depression of appetite and reduced weight gain. Replacement of the amino acid results in the recovery of appetite and growth.

The high protein requirement of fish is directly related to a relatively high indispensible amino acid requirement when compared with pigs, chicks, and rats (Table 5). The requirement for arginine in the eel and carp is considerably higher than that of the young pig and the rat but is only about two-thirds of that of chinook salmon and chicks. Carp require 3.1 percent methionine in their dietary protein in the absence of cystine and 2.3 percent in the presence of 5.2 percent cystine in the dietary protein (or 2 percent cystine in the diet). Channel catfish have a methionine requirement of 2.3 percent in the absence of cystine (Table 5), indicating that a half of the methionine requirement can be replaced by cystine. Methionine requirement for eel was determined to be 3.7 percent in the presence of 1.6 percent cystine, whereas chinook salmon require 1.5 percent of methionine in the presence of 2.5 percent cystine in the dietary protein. Methionine requirement of carp is higher than that of chinook salmon and lower than that of eel. The tryptophan, threonine, and isoleucine requirements of eel are noticeably higher than chinook salmon. The valine, histidine, and leucine requirements of eel are almost the same as that of salmonids. The isoleucine and leucine requirements of young carp are quite similar to those of chinook salmon. The lysine requirement of catfish is higher than that of eel and chinook salmon. More research needs to be done on amino acid requirements for important

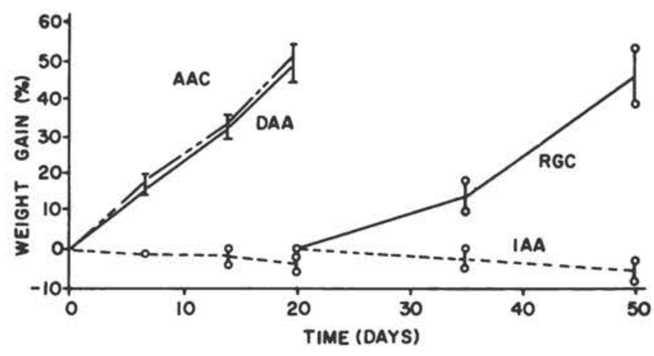

FIGURE 6 Weight gain of fingerling channel catfish fed an amino acid-complete diet (AAC) and 17 amino acid-deficient test diets (DAA and IAA) for 51 days in aquariums. Vertical bars show weight limits at each weight period. Dispensible amino-acid growth curves (DAA) were nearly identical for tyrosine-, glycine-, alanine-, aspartic acid-, glutamic acid-, cystine-, and proline-deficient diets. Indispensible amino acid test diets (IAA) failed to produce growth when arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, or valine were missing from ration. Recovery was prompt when missing indispensible amino acid was replaced in the diet (RGC). SOURCE: Dupree and Halver, 1970.

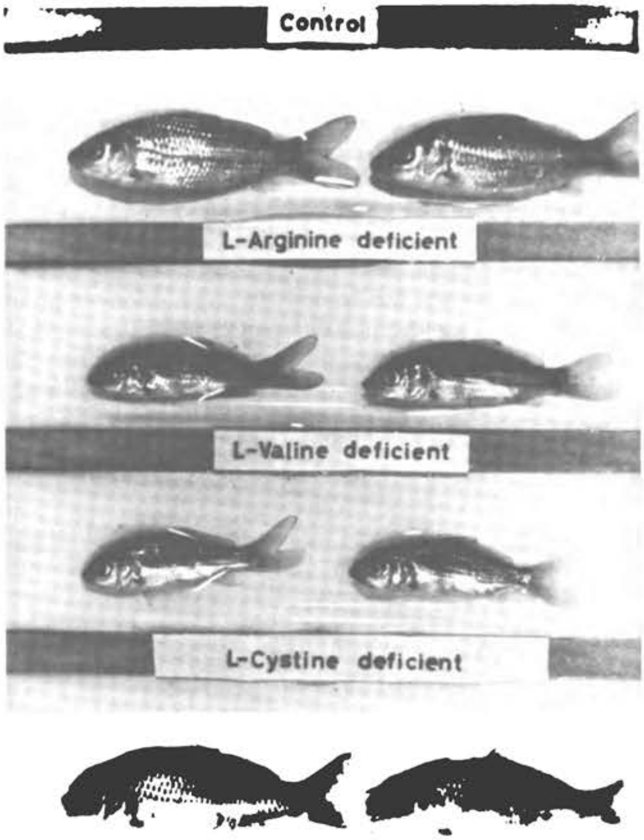

FIGURE 7 Ten amino acids, including arginine and valine, are indispensable for carp. Each will cause general signs of deficiency including poor growth. The dispensible amino acids, such as cystine, can be removed from the diet without indications of deficiency. (Photograph by Nose.)

fishes raised in production facilities to formulate practical diets with the least cost and improved efficiency.

A test diet composed of crystalline amino acids results in satisfactory growth for eel (Figure 8), red sea bream, and shrimp. Supplementation of the most limiting amino acids to a protein diet stimulates growth. Certain other warmwater fishes do not utilize crystalline amino acids efficiently. For example, inferior growth occurs when feeding typical amino acid test diets to carp, catfish, and prawns. This same poor growth is also observed when the protein component is made up of hydrolysates of casein, gelatin, or other proteins. Supplementation with methionine, cystine, and lysine to diets containing soybean meal does not improve growth in channel catfish. Enrichment of protein with supplemental crystalline amino acid(s) may not be effective for growth improvement of carp, catfish, and some species of prawn. However, one species of shrimp shows significant improvement in growth when the soybean meal protein is supplemented with synthetic methionine.

NUTRITIVE QUALITY OF DIETARY PROTEIN

Protein quality is regulated principally by amino acid composition. A ration with the highest protein quality is the one that supplies the indispensible amino acids in optimal amounts and proportions needed for fish protein synthesis.

Animal proteins, in general, have higher nutritive quality for warmwater fishes than plant protein. Replacement of one-third of the protein in all-plant protein diets with fish meal protein improves growth rate and food conversion in channel catfish. Fish meal generally satisfies the demand for indispensible amino acids to most fishes. Soybean meal, the most widely used plant protein, is deficient in sulfur-containing amino acids and is less efficient for growth of fish than fish meal. Wheat germ protein results in a higher

TABLE 5 Amino Acid Requirements of Seven Animals[a]

Amino Acid	Eel Fingerling	Carp Fry	Channel Catfish	Chinook Salmon Fingerling	Chick	Young Pig	Rat
Arginine	3.9 (1.7/42)	4.3 (1.65/38.5)		6.0 (2.4/40)	6.1 (1.1/18)	1.5 (0.2/13)	1.0 (0.2/19)
Histidine	1.9 (0.8/42)			1.8 (0.7/40)	1.7 (0.3/18)	1.5 (0.2/13)	2.1 (0.4/19)
Isoleucine	3.6 (1.5/42)	2.6 (1.0/38.5)		2.2 (0.9/41)	4.4 (0.8/18)	4.6 (0.6/13)	3.9 (0.5/13)
Leucine	4.1 (1.7/42)	3.9 (1.5/38.5)		3.9 (1.6/41)	6.7 (1.2/18)	4.6 (0.6/13)	4.5 (0.9/19)
Lysine	4.8 (2.0/42)		5.1 (1.23/24.0)	5.0 (2.0/40)	6.1 (1.1/18)	4.7 (0.65/13)	5.4 (1.0/19)
Methionine[b]	4.5 (2.1/42)[c]	3.1 (1.2/38.5)	2.3 (0.56/24.0)	4.0 (1.6/40)[c]	4.4 (0.8/18)	3.0 (0.6/20)	3.0 (0.6/20)
Phenylalanine[d]				5.1 (2.1/41)[e]	7.2 (1.3/18)	3.6 (0.45/13)	5.3 (0.9/17)
Threonine	3.6 (1.5/42)			2.2 (0.9/40)	3.3 (0.6/18)	3.0 (0.4/13)	3.1 (0.2/19)
Tryptophan	1.0 (0.4/42)			0.5 (0.2/40)	1.1 (0.2/18)	0.8 (0.2/25)	1.0 (0.2/19)
Valine	3.6 (1.5/42)			3.2 (1.3/40)	4.4 (0.8/18)	3.1 (0.4/13)	3.1 (0.4/13)

[a] Expressed as percent of dietary protein. In parentheses, the numerators are requirements as percent of dry diet, and the denominators are percent total protein in the diet. Data for chinook salmon, chick, pig, and rat are cited from Mertz (1969); data for eel and carp are from unpublished information of S. Arai and T. Nose, respectively.

[b] In the absence of cystine.

[c] Methionine plus cystine.

[d] In the absence of tyrosine.

[e] Phenylalanine plus tyrosine.

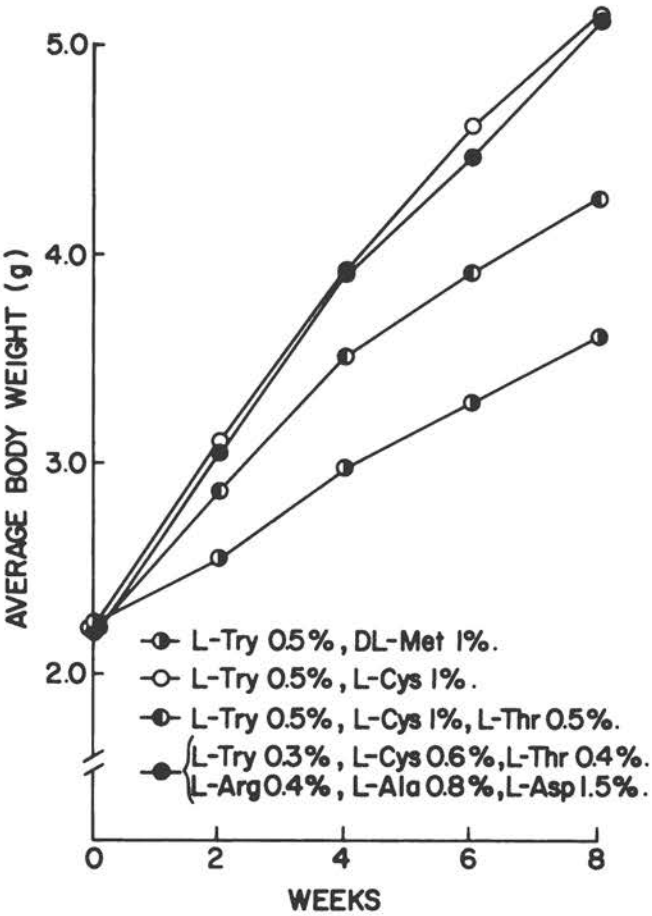

FIGURE 8 Effect of amino acids supplemented to casein-gelatin diets on growth of eel. SOURCE: Arai *et al.*, 1971.

growth rate and feed efficiency than casein in carp. Some single cell proteins, such as the yeast grown on *n*-paraffin, methanol, ethanol, and acetic acid, can be used as alternates for fish meal in rations for carp, eel, and bluegill sunfish. A combination of fish meal and yeast results in a higher growth rate and food efficiency than fish meal used as the sole source of protein for carp.

PROTEIN-TO-ENERGY RELATIONSHIP

Nonprotein energy in practical diets influences the quantity of protein required for optimum growth. Insufficient nonprotein energy in the ration causes part of the dietary protein to be metabolized and used for energy. Excessive dietary energy intake may restrict protein consumption and subsequent growth. The concept of calorie-to-protein ratio (kcal:g) must be restricted to diets containing adequate energy and protein. Fish fed diets with varying levels of energy and protein but having the same calorie-to-protein ratio will yield significantly different growth rates (Figure 9). Optimal energy-to-protein ratios for practical catfish diets have been determined to be between 6.5 and 8.3 kcal of digestible energy per g of protein.

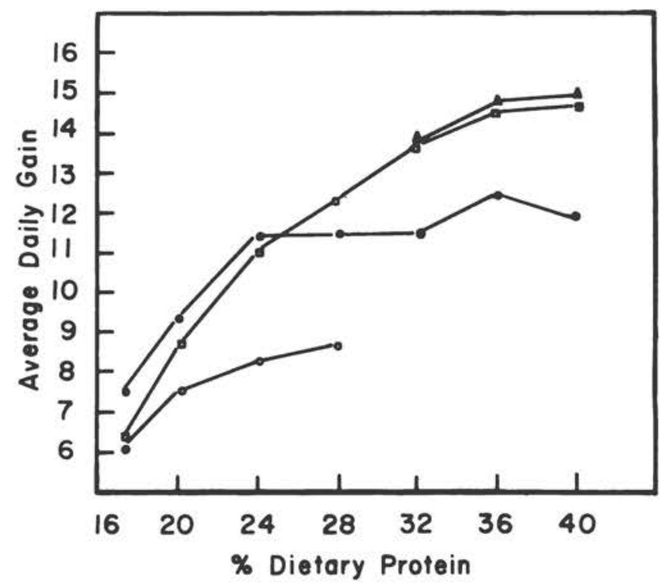

FIGURE 9 The average daily gain of channel catfish fed semipurified diets with varying levels of protein at energy levels of 209 (O), 275 (●), 341 (∟), or 407 (Δ) kcal metabolizable energy (ME)/100 g diet. SOURCE: Garling, 1975.

LIPIDS

Dietary lipids play important roles in the nutrition of warmwater fishes as energy sources, phospholipid and steroid components of vital organs, and in maintenance of neutral bouyancy. The lipid characteristics of fish tissues, which may be influenced by dietary and environmental factors, are important in taste and storage properties of fishery products.

LIPID UTILIZATION

Environmental temperatures and melting points both have an important bearing on the digestibility of dietary lipids. If the melting points of dietary lipids are above the environmental temperature (or the body temperature of the poikilothermic animal), lipids solidify in the gastrointestinal tract and are poorly digested. At temperatures above 20° C, warmwater fishes are able to efficiently utilize saturated fats such as beef tallow, which are poorly digested by coldwater species.

Studies have indicated that hydrogenated corn oil is better utilized by catfish than unsaturated corn oil, which contains a high level of linoleic acid. Other studies have demonstrated that beef tallow is equal to highly unsaturated menhaden oil as an energy source at temperatures above 20° C. Lipids of intermediate degrees of unsaturation such as olive, safflower, and corn oils are not utilized by catfish as efficiently as beef tallow or menhaden oil. Dietary triglycerides have been shown to be more efficiently utilized by catfish than free fatty acids or ethyl esters.

LIPID LEVEL

Very little data have been reported on the optimal lipid levels for warmwater fishes. Practical-type rations with lipid levels up to 12 percent have been reported to be utilized efficiently by catfish reared at 28° C, while 5 percent dietary lipid was sufficient for fish at 23° C. Dietary lipid levels up to 15 percent in semipurified diets have shown growth-enhancing or "protein-sparing" effects.

Commercial diets for carp for use at warmwater temperatures may contain 10 to 15 percent fat, while lower fat levels are used at temperatures below 20° C. Eel diets may contain up to 10 percent fat. Common commercial diets for ayu usually contain 5 percent fat or less.

ESSENTIAL FATTY ACIDS

The only essential fatty acid (EFA) syndrome that has been reported in warmwater fishes (catfish, eel, and carp) is reduced growth and an increase in the tissue level of the characteristic EFA deficiency acid (5,8,11-eicosatrienoic acid; 20:3 $\omega 9$; the letter ω followed by a number indicates the position of the first double bond from the terminal or hydrocarbon end of the fatty acid). Dietary linoleate or linolenate will prevent this buildup in all three species and enhance growth in carp and eel. However, high levels of linoleate have resulted in reduced growth in catfish.

The requirements of catfish for $\omega 3$ or $\omega 6$ fatty acids may be extremely low, as excellent growth rates have been obtained in long-term studies with beef tallow as the sole source of lipid, despite a buildup of high tissue levels of 20:3 $\omega 9$ acid. Additional research is needed on EFA requirements of warmwater fishes.

LIPID METABOLISM

Environmental temperatures have a great influence on the physical and chemical properties of lipids and lipid metabolism in fishes. In general, the carcass lipid levels of fish increase and the amounts of polyunsaturated fatty acids in tissues decrease at higher environmental temperatures (Figures 10 and 11).

The nature of fish tissue fatty acids is markedly influenced by dietary lipids. Fish can synthesize saturated fatty acids and members of the $\omega 9$ and $\omega 7$ families of unsaturated acids; however, a dietary source is required for the $\omega 3$ and $\omega 6$ families to be present in fish tissues. In general, almost all marine fishes contain large amounts of $\omega 3$ polyunsaturated

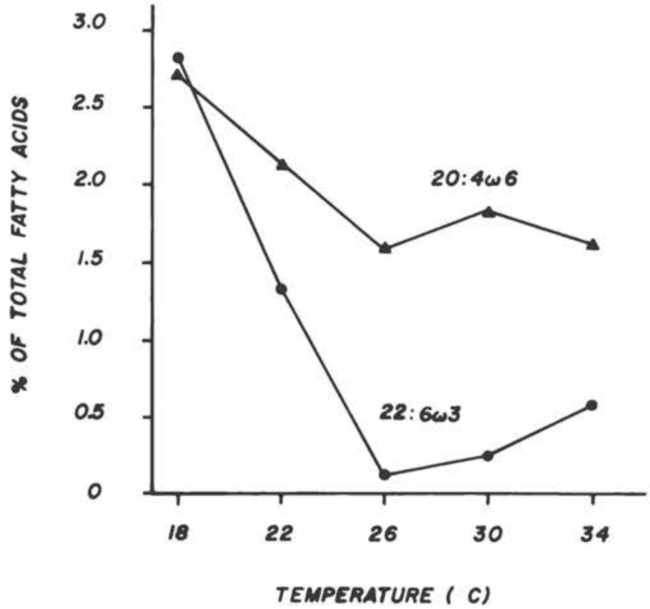

FIGURE 10 The influence of environmental temperature on the level of arachidonic and 4,7,10,13,16,19-docosahexaenoic acid in channel catfish fingerlings. SOURCE: Andrews and Stickney, 1972.

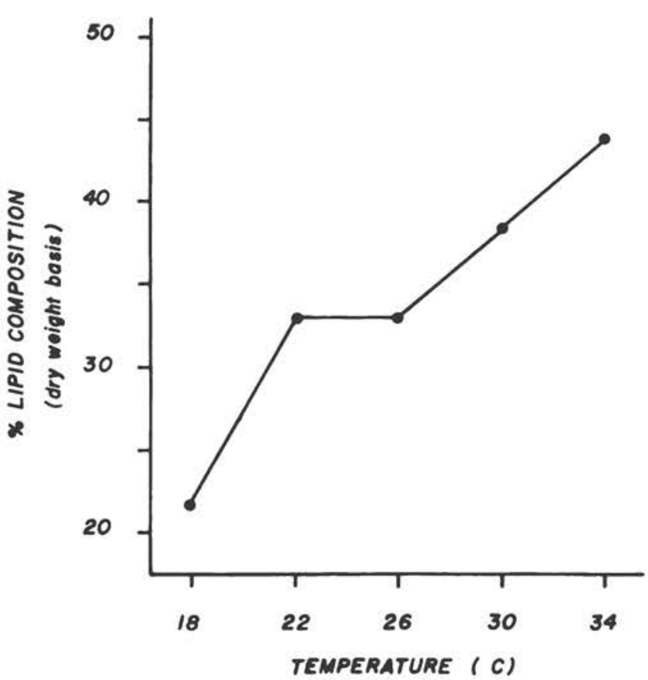

FIGURE 11 The influence of environmental temperature on whole carcass lipid content (expressed as a percentage of dry weight of carcass) in channel catfish fingerlings. SOURCE: Andrews and Stickney, 1972.

fatty acids containing 20-22 carbon atoms with five and six double bonds. However, some freshwater fishes contain very low levels of 20-22 carbon fatty acids and appreciable amounts of ω6 fatty acids that originate in terrestrial plants. Total body lipid levels of greater than 50 percent dry weight have been reported in warmwater fishes. Certain warmwater fishes contain high levels of unusual lipids such as odd-chained fatty acids, branched-chained fatty acids, hydrocarbons, glyceryl ethers, steryl esters, wax esters, and fatty acid amides.

TOXIC EFFECTS

Storage problems may arise in diets that contain high levels of polyunsaturated fatty acids that are easily oxidized into

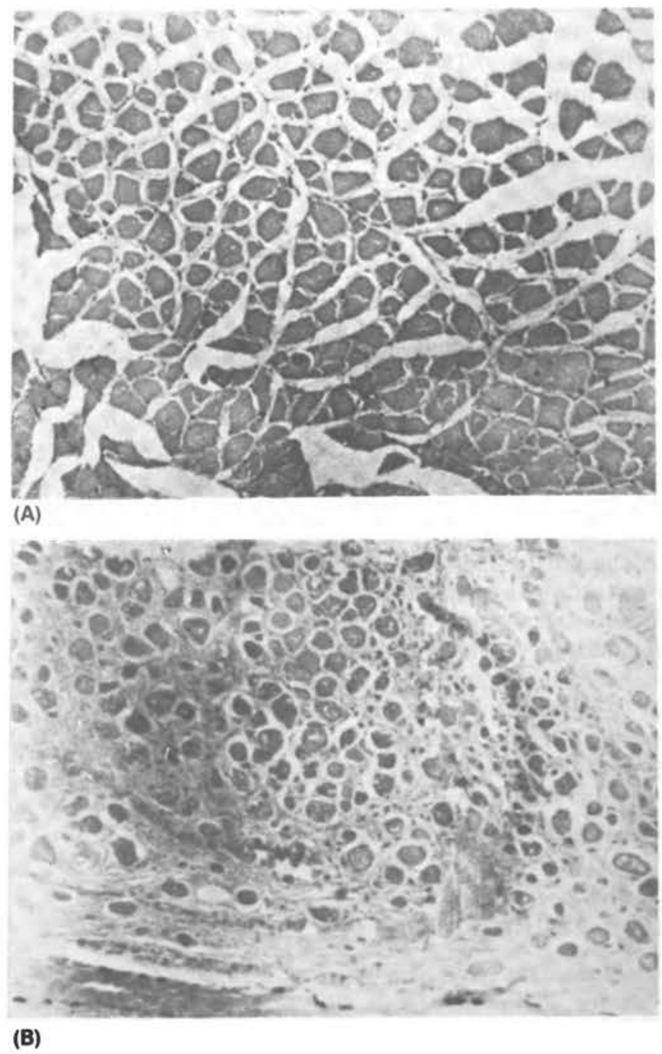

FIGURE 12 Lateral muscle sections of normal fish (A) and tocopherol-deficient dystrophic fish (B) with granular degeneration of muscle fibers and hyperplasia of perimysium (H & E × 100). (Photograph by Murai and Andrews, 1974.)

peroxides and other toxic compounds. Diets containing high levels of oxidized lipids and low levels of α-tocopherol, or other antioxidants, may result in poor growth and survival rates, anemia, high incidences of exudative diathesis, muscular dystrophy (Figure 12), depigmentation, degradation of pancreatic tissue, and other adverse effects. The occurrence of this condition can be retarded by the addition of α-tocopherol or other antioxidants to fish diets.

CARBOHYDRATES AND FIBER

CARBOHYDRATES

Carbohydrates are considered the least expensive form of dietary energy for man and domestic animals, but utilization by warmwater fishes varies and remains somewhat obscure. Dietary carbohydrates are known to be utilized by various fishes, but only limited information is available on their digestibility and metabolism.

Intermediary Metabolism

Carbohydrates are absorbed as simple sugers by fishes. The various enzymes involved in glucose oxidation have been investigated in several fishes with respect to tissue activities, distribution, and, to a limited extent, kinetic properties. All of the enzymes of the Embden-Myerhoff-Parnas pathway have been demonstrated. Only a limited number of detailed studies have been reported on the kinetic properties of these various enzymes, and the results are consistent with evolutionary development.

Even though the various enzymes and pathways for glucose metabolism have been detected in fishes, the role of dietary carbohydrates and the contribution of glucose to the total energy requirement of fishes remain unclear. Studies have indicated that the hormonal and metabolic regulation of carbohydrate and energy metabolism may be somewhat different in fishes than in mammals.

Sekoke disease, a spontaneous diabetes in carp, has been characterized. The major metabolic aspects of this disease are hyperglycemia, decreased glucose tolerance, glycosuria, and acidosis, which is similar to classical diabetes mellitus. Studies on the cause of the disease indicate that it may be due to a hormonal imbalance (hydrocortisone) as well as an insufficiency of insulin.

Evidence indicates that carp utilize protein and lipid preferentially to carbohydrate for metabolic energy. Liver glycogen remains relatively constant, while the lipid and protein contents decrease during starvation. Carp oxidize amino acids for energy more readily than glucose. Depot fat is synthesized from amino acids and dietary lipids preferentially to carbohydrates.

Studies with the eel indicate that plasma amino acids are utilized by the tissue as a noncarbohydrate source for the synthesis of glucose in a manner similar to that found in higher animals.

Value of Carbohydrates in Warmwater Fish Rations

There are no carbohydrate requirements for warmwater fishes. However, carbohydrates can spare protein in channel catfish rations. The beneficial effects of carbohydrates in rations differ with the complexity of the carbohydrate. Channel catfish were found to utilize polysaccharides, such as dextrin, for growth more readily than disaccharides or simple sugars. On the other hand, higher growth rates and feed efficiencies were reported on red sea bream fed diets with glucose than those with dextrin or cooked starch at the 20-percent level. Thus, the utilization of carbohydrates differs among the species of fish reflecting the processes of digestion, absorption, or internal metabolism of carbohydrates. In addition to serving as an inexpensive source of energy, the starches aid in the pelleting quality of rations.

Carbohydrates may also serve as precursors for the various metabolic intermediates necessary for growth, i.e., nonessential amino acids and nucleic acids. Thus, in the absence of adequate dietary carbohydrate or lipids, the fish makes inefficient use of dietary protein to meet its energy and other metabolic needs. This relationship between protein and carbohydrates has often been referred to as the protein-sparing action of carbohydrates.

FIBER

The physiological role of indigestible dietary materials, such as plant cell wall materials, which are usually referred to as fiber, has not been investigated extensively in fish nutrition. Studies with channel catfish have shown that fiber is not a necessary component in production rations for optimum rate of growth or nutrient digestibility. In purified experimental diets, containing readily solubilized nutrient sources, added fiber may improve nutrient assimilation.

Fiber may serve a role in fish rations as a diluent for other nutrients and as an extender in the ration to help insure equitable distribution of nutrients to all fish. Levels as high as 21 percent reduce nutrient intake and impair digestibility in practical diets for channel catfish. Fiber in concentrations of less than 8 percent may add structural integrity to pelleted diets, but larger amounts may impair pellet quality. Since fiber is poorly digested by fish, most of that in the diet ultimately becomes a pollutant in the culture system.

VITAMINS AND MINERALS

VITAMINS

Need for vitamins in the diet of warmwater fishes is well documented. Quantitative requirements were not considered important prior to 1950. Supplements were seldom used since the fish were assumed to obtain the needed vitamins from natural foods in their environment. Supplemental vitamins in rations became important when fishes were reared intensively in ponds, raceways, or cages where natural foods were limited or nonexistent.

Most of the research on vitamins for warmwater fishes has consisted of feeding purified rations to develop deficiency signs and determine quantitative requirements. Practical rations were tested to determine adequate amounts of vitamin supplementation necessary for maximum growth and good health when fed to fish in ponds, raceways, and cages.

Requirements

Vitamin requirements for fishes are affected by size, age, growth rate, environmental stresses, water temperature, and nutrient interrelationships. The quantitative effects of these variables have not been evaluated adequately.

Vitamin requirements are usually presented as a function of the ration formulation. The recommended allowances given in Table 6 are based upon experimental feeding trials, primarily with channel catfish, carp, and eel. Vitamin recommendations among these species were found to be similar. Requirements may be different for brood fish, fish growing at varying rates or at different water temperatures, or fish fed different nutrient rations.

Vitamin Supplements

Practical rations for warmwater fishes may be termed complete or supplemental. Supplemental rations are formulated primarily to meet protein and energy requirements with the presumption that the fishes obtain some vitamins and other growth factors by eating food organisms from their environment. Complete rations are formulated to contain adequate amounts of all nutrients for satisfactory growth of the fish (Figure 13).

TABLE 6 Recommended Allowance for Vitamins in Supplemental and Complete Diets for Warmwater Fishes

Vitamin	Amount (per kg) in Dry Diet[a] Supplemental	Complete
Vitamin A activity	2,000 IU	5,500 IU
Vitamin D_3 activity	220 IU	1,000 IU
Vitamin E	11 IU	50 IU
Vitamin K	5 mg	10 mg
Choline	440 mg	550 mg
Niacin	17-28[b] mg	100 mg
Riboflavin	2-7[b] mg	20 mg
Pyridoxine	11 mg	20 mg
Thiamin	0	20 mg
D-Calcium pantothenate	7-11[b] mg	50 mg
Biotin	0	0.1 mg
Folacin	0	5 mg
Vitamin B_{12}	2-10 μg	20 μg
Ascorbic acid	0-100[b] mg	30-100[b] mg
Inositol	0	100 mg

[a] These amounts do not allow for processing or storage losses. Other amounts may be more appropriate for various species and under various environmental conditions.

[b] Highest amounts probably appropriate when "standing crop" of fish exceeds 500 kg/hectare of water surface.

The vitamin supplement added to a ration is commonly termed a premix. This premix is formulated to supplement the vitamins contained in ration ingredients, or to compensate for vitamins not completely available and losses occurring during processing and storage. A vitamin allowance that only meets the minimun requirements (from ingredients and added premix) leaves little margin of safety.

A modest excess of vitamins is recommended for several reasons: antimetabolites may reduce the activity of some

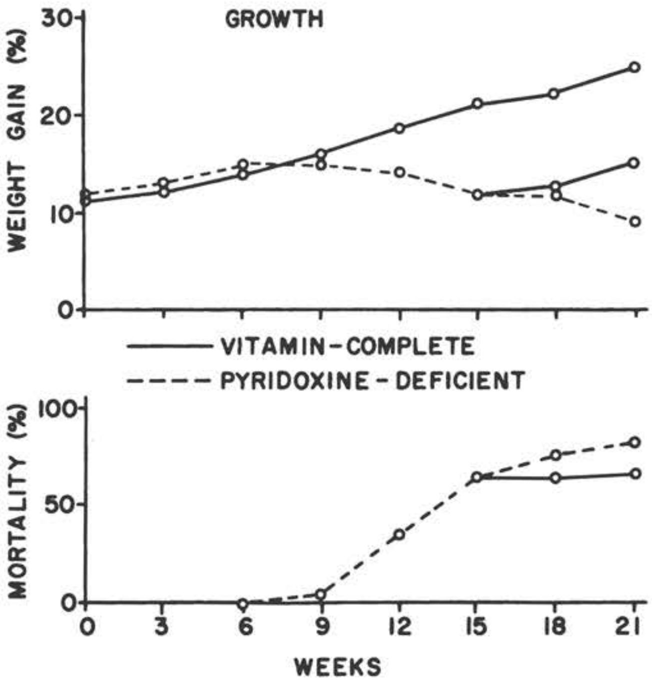

FIGURE 13 Deletion of a vitamin, such as pyridoxine, from the diet will cause stored vitamin to be used. Fish will show signs of vitamin deficiency, reduced growth, and increased mortality as these sources are depleted. Normal growth will be restored and mortality will cease when the vitamin is added to the diet at a level required by the fish. SOURCE: Dupree, 1966.

vitamins in the diet or in the fish; oxidative losses of vitamins are accelerated by heat, moisture, rancid oils, metals, and other oxidants; the vitamin contents of ration ingredients vary considerably; and allowance must be made for leaching of vitamins from the diet by water.

Vitamin Requirements and Deficiency Signs

Vitamin test diets prepared from purified ingredients to which all crystalline vitamins except the one being evaluated have been used to determine essentiality of the water-soluble and fat-soluble vitamins for warmwater fishes. Those vitamins shown to be essential in the diet of channel catfish, eel, carp, red sea bream, and yellowtail with resulting deficiency signs are summarized in Table 7 and Figures 14, 15, 16, 17, 18, 19, and 20. A typical growth depression and mortality curve and the subsequent recovery curve when the vitamin is replaced in the diet is shown in Figure 13.

Studies have been conducted to determine the quantitative requirements for each of the essential vitamins. Purified test diets were used containing all the essential nutrients except the vitamin being studied. Graded amounts of the deleted vitamin were added to these diets and fed to test lots of fish. The minimum amount of vitamin resulting in maximum growth and acceptable tissue storage and absence of deficiency signs was concluded to be the quantitative dietary need for that vitamin.

TABLE 7 Essential Vitamins and Deficiency Signs in Warmwater Fishes

Vitamin	Deficiency Signs
Thiamine	Poor appetite, muscle atrophy, convulsions, instability and loss of equilibrium, edema, poor growth, congestion of fins and skin, fading of body color, lethargy.
Riboflavin	Corneal vascularization, cloudy lens, hemorrhagic eyes, photophobia, incoordination, abnormal pigmentation of iris, striated constrictions of abdominal wall, dark coloration, poor appetite, anemia, poor growth, hemorrhage in skin and fins.
Pyridoxine	Nervous disorders, epileptiform fits, hyper-irritability, ataxia, anemia, loss of appetite, edema of peritoneal cavity, colorless serous fluid, rapid onset of rigor mortis, rapid breathing, flexing of opercles, iridescent blue coloration, exophthalmos.
Pantothenic acid	Clubbed gills, necrosis, scarring and cellular atrophy of gills, gill exudate, prostration, loss of appetite, lethargy, poor growth, hemorrhage in skin, skin lesions and dermatitis.
Inositol	Distended stomach, increased gastric emptying time, skin lesions, poor growth (Figure 14).
Biotin	Loss of appetite, lesions in colon, altered coloration, muscle atrophy, spastic convulsions, fragmentation of erythrocytes, skin lesions, poor growth (Figure 15).
Folic acid	Lethargy, fragility of caudal fin, dark coloration, macrocytic anemia, poor growth.
Choline	Poor food conversion, hemorrhagic kidney and intestine, poor growth, accumulation of neutral fat in hepatopancreas, enlarged liver.
Nicotinic acid	Loss of appetite, lesions in colon, jerky or difficult motion, weakness, edema of stomach and colon, muscle spasms while resting, sensitivity to sunlight, poor growth, hemorrhage in skin, tetany, lethargy, anemia.
Vitamin B_{12}	Poor appetite, low hemoglobin, fragmentation of erythrocytes, macrocytic anemia, reduced growth.
Ascorbic acid	Scoliosis, lordosis, impaired formation of collagen, abnormal cartilage, eye lesions, hemorrhagic skin, liver, kidney, intestine, and muscle, reduced growth (Figures 16, 17, 18, and 19).
Vitamin A	Ascites, edema, exophthalmos, hemorrhagic kidneys, poor growth (Figure 20).
Vitamin E (α-tocopherol)	Ascites, ceroid in liver, spleen, and kidney, epicarditis, exophthalmia, microcytic anemia, pericardial edema, fragility of red blood cells, poor growth.
Vitamin K	Anemia, prolonged coagulation time.

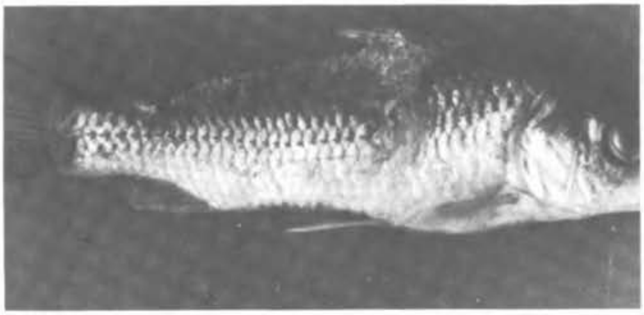

FIGURE 14 Inositol deficiency of carp showing skin lesions and fin damage. (Photograph by Aoe.)

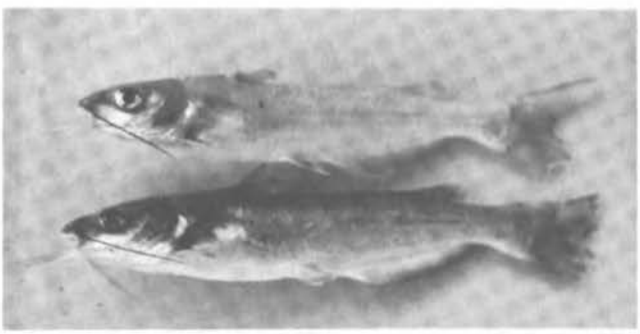

FIGURE 15 Channel catfish fed a high-lipid, biotin-free diet containing a biotin antagonist, avidin, show lack of pigmentation in the skin and reduced growth rate (top) when compared to fish fed a diet sufficient in biotin (bottom). (Photograph by Lovell.)

FIGURE 16 Channel catfish fed semipurified diets with ascorbic acid (top) and without ascorbic acid (bottom) for 10 weeks in aquariums. The ascorbic acid-deficient fish (bottom) shows both vertical (lordosis) and lateral (scoliosis) curvature of the spine. (Photograph by Lovell.)

FIGURE 17 Radiograph of channel catfish fed a practical diet without supplemental ascorbic acid for 180 days to a size of 400 g. The fish shows lateral dislocation of the vertebrae (scoliosis). (Photograph by Lovell.)

FIGURE 18 "Broken back syndrome" may be a problem when channel catfish are fed commercial rations without supplemented ascorbic acid in culture systems devoid of natural pond organisms. Spinal separation usually occurs near the first vertebra posterior to the rib cage. (Photograph by Lovell.)

FIGURE 19 Anterior view of an eel showing hemorrhaging and erosion of the lower jaw resulting from ascorbic acid deficiency. (Photograph by Nose.)

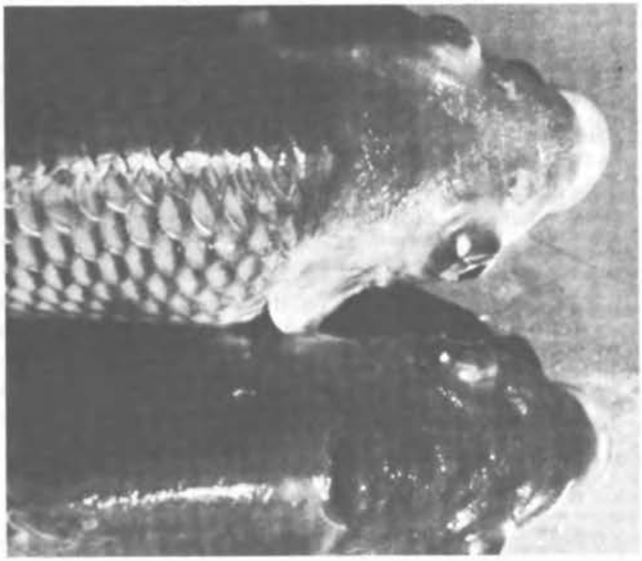

FIGURE 20 Vitamin A deficiency of carp showing typical exophthalmos. (Photograph by Aoe.)

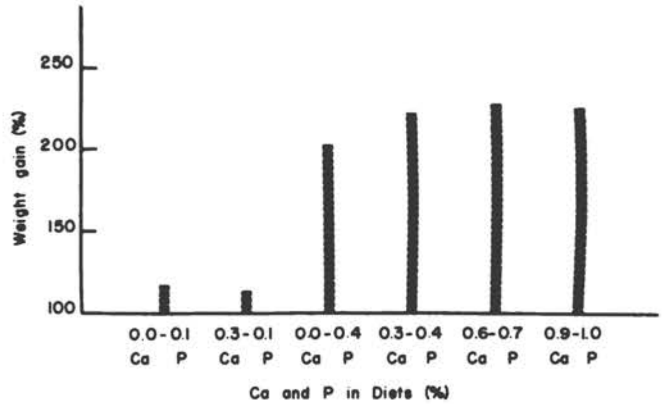

FIGURE 21 Weight increases of channel catfish fed semipurified diets containing various levels of inorganic calcium (Ca) and phosphorus (P) in a controlled environment. The water contained 14 mg/l of Ca and 0.03 mg/1 of P. Supplementation of the control diet (0.0 percent Ca; 0.01 percent P) with Ca alone yielded no improved growth. Addition of P improved diet performance appreciably. SOURCE: Lovell, 1971.

MINERALS

Inorganic elements required by other animals for tissue formation and various functions in metabolism and regulation are probably required by fish. Fish also utilize inorganic elements to maintain osmotic balance (osmoregulation) between fluids in the animal's tissues and water in the environment.

Mineral requirements of fish are difficult to study because of absorption from both the water and the food. Diet ingredients devoid of the test minerals are difficult to obtain. The contribution from the water can meet the requirement for some minerals but may be insignificant for others. Calcium is often present in high concentrations in water and may eliminate the need for a dietary source.

Calcium and Phosphorus

Fish, like mammals, require relatively large quantities of calcium and phosphorus for growth and metabolism as compared with the other essential minerals. Unlike land animals, the ratio of calcium to phosphorus in the diet is not critical unless the dissolved calcium in the water is very low. Carp, rainbow trout, and red sea bream can absorb sufficient calcium from water containing relatively high levels of calcium if the diet is adequate in phosphorus. Channel catfish benefit only slightly from dietary calcium; however, the eel is relatively sensitive to a calcium-deficient diet.

Amounts of soluble phosphate are low in some natural waters; consequently, added dietary phosphate will markedly improve fish growth (Figure 21), body content of calcium and phosphorus, and appetite. Deformed backs (lordosis) and heads have been associated with phosphorus deficiency in carp (Figure 22). Phytate phosphorus is poorly utilized by fishes. Phosphorus from fish meal is less than 50 percent digested by channel catfish and even less digestible to the stomachless carp.

Minimum requirements of available phosphorus in diets of eel, channel catfish, carp, and red sea bream have been found to be 0.3, 0.45 to 0.8, 0.6 to 0.75, and 0.65 percent, respectively.

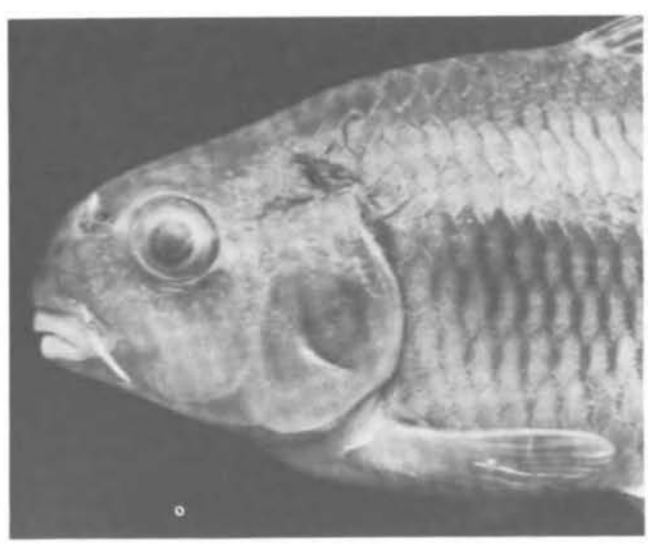

FIGURE 22 Phosphorus deficiency in carp causes reduced bone growth, especially noticable in skull and operculum. Reduced growth of the skull results in exophthalmos. (Photograph by Aoe.)

TABLE 8 Mineral Mixtures for Purified and Practical Warmwater Fish Diets

Mineral	Dry Diet (g/100 g)
Purified Diets	
$CaHPO_4 \cdot 2H_2O$	2.07
$CaCO_3$	1.48
KH_2PO_4	1.00
KCl	0.10
NaCl	0.60
$MnSO_4 \cdot H_2O$	0.035
$FeSO_4 \cdot 7H_2O$	0.05
$MgSO_4$	0.30
KIO_3	0.001
$CuSO_4 \cdot 5H_2O$	0.003
$ZnCO_3$	0.015
$CoCl_2$	0.00017
$NaMoO_4 \cdot 2H_2O$	0.00083
Na_2SeO_3	0.00002
Practical Diets	
$CaCO_3$	0.750
$MnSO_4 \cdot H_2O$	0.030
$ZnSO_4 \cdot 7H_2O$	0.070
$CuSO_4 \cdot 5H_2O$	0.006
$FeSO_4 \cdot 7H_2O$	0.050
NaCl	0.750
KIO_3	0.0002
$CaHPO_4 \cdot 2H_2O$	2.00

Other Essential Inorganic Elements

Dietary requirements for most of the other minerals have not been established for warmwater fishes. The minimum requirement for magnesium in carp has been determined to be 0.05 percent of the diet. Differences in growth responses have been established by changing dietary levels of magnesium, potassium, copper, and iodine. High dietary levels of potassium, iron, zinc, copper, iodine, and molybdenum have resulted in growth depression. Subnormal hematocrit levels have been measured in fish fed diets low in iron and copper.

Mineral mixtures that supply all necessary dietary inorganic elements to fishes are given in Table 8. The mineral composition and quantities of each were derived from assumptions of mineral needs by the fish and through experience in the use of diets containing the mineral supplements.

TOXINS AND ANTIMETABOLITES

Toxins that may be present in fish feedstuffs are mycotoxins, toxic products in plant products, residues of pesticides, and other agricultural and industrial chemicals.

Mycotoxins affect many animals, including fishes. Brown-bullhead and rainbow trout are affected by very low levels of these materials, but channel catfish are much less sensitive. These toxins are found in many molds on plant materials, including cottonseeds, peanuts, soybeans, farm grains, and by-products of processed oil seeds.

Other toxins and antimetabolites in plant materials include protease inhibitors, hemagglutinins, goitrogens, cyanogens, saponins, and gossypol. Improper processing of feedstuffs may result in residual activity of these compounds.

The intensively studied trypsin inhibitor of soybeans and other oil seeds is destroyed by proper processing. Other toxic plant materials may be destroyed or the effects minimized by processing (e.g., heating, chemical treatment, or extraction).

Residues of pesticides, herbicides, and other agricultural or industrial chemicals in feedstuffs have resulted in economic losses in fish culture. Sources of residues can often be traced to the field where the foodstuff was produced. Accidental contamination with various toxic materials may occur during processing, shipping, and storage of foods or feedstuffs (Figure 23, p. 24). Excesses of inorganic elements in fish rations, because of errors in formulating or processing or because of other inadvertent circumstances, may produce toxicological effects in fishes.

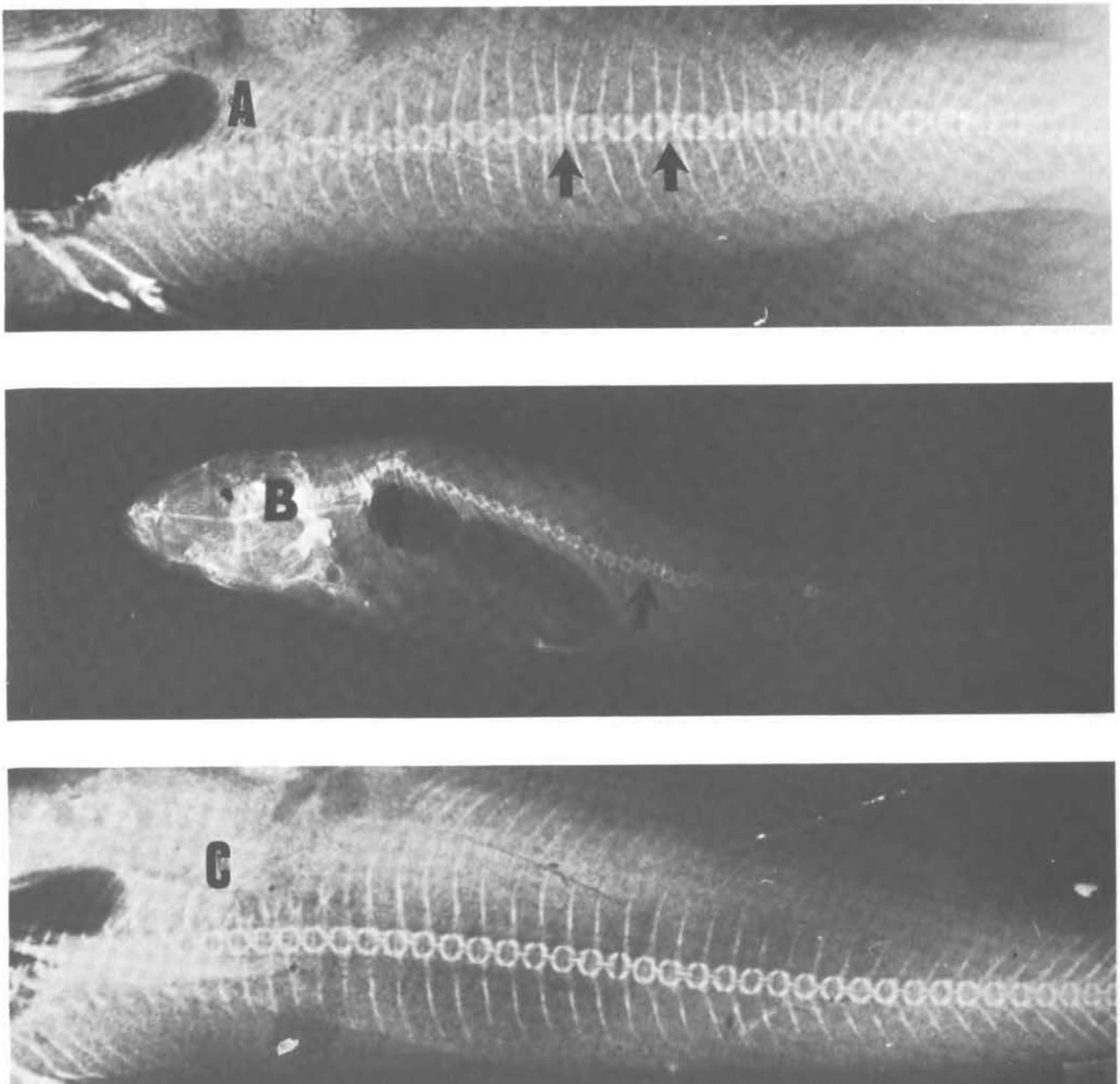

FIGURE 23 Radiographs showing the effects of toxaphene on the backbone structure of channel catfish (A) and fathead minnow (B). Backbone of a normal catfish (C) does not show deformity. Channel catfish (A) was exposed to 44 ng of toxaphene per liter of water and fathead minnow (B) was exposed to 55 ng of toxaphene per liter of water. Arrows indicate areas of affected backbone. (Photographs by Mehrle and Mayer, 1975.)

INFLUENCE OF CULTURAL PROCEDURES ON DIETARY REQUIREMENTS

Most warmwater fishes are raised in ponds where nutrients from aquatic organisms make slight to significant contributions to their dietary requirements. The magnitude of contribution from natural foods to nutrition of fish depends upon productivity of the pond, size and number of fish, and species. Yields of 300 to 400 kg of channel catfish or carp can be produced per hectare (ha) without supplemental feeding. Efficient plankton and benthic feeders such as *Tilapia* species and milkfish have yielded 1,500 to 1,800 kg/ha with only pond fertilization.

Pond culture of fish should always take maximum advantage of nutrients produced in the pond. Natural food organisms can supply significant amounts of macronutrients as well as micronutrients with low total fish populations. Even with high populations of fish, some essential nutrients may be omitted or reduced in quantity in rations fed to fish in ponds that are balanced with regard to natural food production and fish density. For example, channel catfish usually do not need supplemental ascorbic acid in their ration when grown in fertile ponds at densities not exceeding 3,000 to 4,000 kg of fish per ha. At higher densities, or in cages or raceways, supplemental ascorbic acid in the ration is necessary to prevent reduced growth rate and incidence of the deficiency syndrome (Table 8, Figure 16).

Practical fish culture has shown that it is unnecessary and uneconomical to balance supplemental rations for pond-fed fish according to the absolute nutrient requirements of the fish. Consequently, nutrient allowances for *supplemental* as well as *complete* rations should be made availale to fish culturists. A supplemental ration is one fed to fish that receive a portion of their nutrient requirements from pond organisms. A complete ration is one supplying all nutrients in amounts necessary for a satisfactory rate of performance by fish that do not have access to other sources of food. Difficulty arises in making nutrient recommendations for supplemental rations because the nutrient contribution of pond organisms cannot be predicted with accuracy. Also, as density of fish in the pond increases, nutrients from pond organisms provide a proportionately smaller percentage of the fish's dietary needs.

VITAMINS

The vitamin allowances for supplemental rations presented in Table 6 have provided satisfactory growth for channel catfish at pond densities up to 3,300 kg/ha, which is near the maximum density in conventional pond culture.

MINERALS

Minerals dissolved in the water and from pond organisms may each contribute to the inorganic nutrient requirements of fish. Many freshwater fishes can absorb enough calcium from the water to meet their needs provided the diet is adequate in phosphorus and the dissolved calcium is not unusually low. Phosphorus, however, is not usually found in solution in pond waters in sufficient concentration for the water to be a significant nutritional source.

Pond studies with channel catfish have demonstrated that all-plant rations should be supplemented to increase available phosphorus levels to 0.52 percent of the ration. When limited amounts of animal products are used in fish rations, a trace mineral supplement containing iron, magnesium, copper, zinc, cobalt, manganese, and iodine should be added to prevent a possible deficiency of one or more of these elements.

PROTEINS AND ENERGY

Protein and energy contributions from pond organisms decrease in importance as the standing crop of fish increases. When the fish are small, or the stocking density is low, aquatic fauna (rotifers, molluscs, insects, and crustaceans), which contain 50 to 75 percent (moisture-free) high-quality protein, make valuable contributions to the diets of omnivorous fishes, and plankton algae, which contain up to 30 percent (moisture-free) protein, provide significant dietary contributions to plankton-feeding fishes.

As fish biomass increases and competition for natural food increases, the protein and energy allowances in supplemental fish rations approach those recommended for complete diets. For example, a research study indicated that standing crops of channel catfish of 110, 1,560, and 2,500 kg/ha obtained approximately 47, 11, and 4.5 percent, respectively, of their assimilated protein from pond organisms.

FEEDING RATE

Another influence of cultural practices on nutritional allowances in fish rations is the relationship between feeding rate and nutrient concentrations in the diet. Daily ration allowances fed in static ponds are usually limited to amounts that the pond ecosystem can utilize safely. Heavily fed ponds produce dense growths of phytoplankton that, in addition to oxidation of the diet offered, create heavy oxygen demands upon the culture system. The maximum daily ration allowance generally recommended for channel catfish in static ponds is approximately 35 kg/ha. Studies have shown that channel catfish fed to harvestable size under such feeding restrictions, i.e., where food allowance could not be increased throughout the growing period as fish weight increased, gained appreciably more when fed rations containing 36 percent protein than when fed rations containing lower percentages of protein of equal quality. Under culture conditions where catfish could be fed as much as they would consume, dietary protein levels less than 36 percent were adequate for maximum growth but not for maximum efficiency.

TEMPERATURE

Environmental temperature has a marked effect on nutrient metabolism in poikilothermic animals. Inasmuch as pond temperatures vary considerably over the growing season in temperate zones, this factor should be considered in formulating diets for use of pond fishes. In pond culture, the water temperature may vary over the growing season as much as 15 degrees. Research with several fish species indicated that fish have higher protein requirements at high temperatures than at low temperatures. For channel catfish, plant proteins have higher biological value at high than at low temperatures, but animal protein values are relatively independent of temperature. Generally, fish utilize saturated fats less efficiently at low than at high temperatures. Low temperature causes reduced utilization of carbohydrates in several species. More research data are needed on the effects of water temperature on nutrient requirements of warmwater fishes. Nutritional recommendations for various temperatures would determine economic yield in commercial fish culture.

PIGMENTATION

External pigmentation is important in some species of food fish, such as red sea bream in Japan, and is essential in ornamental or aquarium fishes. Diet is the source of pigments. Carotenoids are the major pigment compounds and are abundant in natural aquatic flora and fauna. When fish do not have access to such natural foods, pigment supplements must be placed in prepared diets for color development. Meals from various crustaceans (which include the carapace), kelp, and dehydrated alfalfa leaves are sources of pigments. Superior sources are meals or extracts from flower petals and high-carotenoid varieties of algae. Marigold petal meal, or extract, is a highly concentrated source of carotenoids that is used commercially in poultry diets and imparts yellow to red color to aquarium fishes. Canthanxanthin is sometimes added to salmonid diets to impart color to the fish; however, this compound cannot be legally used for food fishes in the United States without specific government clearance.

Desirable coloration in ornamental fishes can be obtained with 20 to 25 xanthophyll units (mg of xanthophyll) per kg of diet. Special diets for rapid pigment development should contain 50 to 60 xanthophyll units per kg. The pigment concentrate should be stabilized or an antioxidant used in the diet preparation to prevent oxidative destruction of pigment compounds.

FISH FEED PROCESSING AND STORAGE

Early experiments demonstrated that diets for catfish and carp fed in meal forms were not as efficiently utilized as pelleted forms. When large fish are fed small-particle feeds, or feeds containing significant amounts of poorly bound ingredients (feed dust), the smaller particles may not be ingested, resulting in lowered feed conversion efficiency. An additional problem unique to fish feeding is that these unconsumed feed particles cause eutrophication of the culture system, which usually results in decreased dissolved oxygen levels, increased growth of undesirable phytoplankton, and a buildup of waste metabolites. To minimize these undesirable effects on the environment and increase feed efficiency, most commercial fish feeds are processed into water-stable particles of a size and texture commensurate with the feeding preferences of the cultured fish species.

PELLETING

Pelleting involves the use of moisture, heat, and pressure to agglomerate ingredients into larger homogenous particles. Steam or hot water added to the ground feed mixture (mash) during pelleting gelatinizes starch, which aids in binding ingredients. Generally, an amount of steam is added to the mash to increase its moisture content to approximately 16 percent and temperature to about 85° C before passing through the pellet die; however, ingredient composition will influence these conditions. The moisture must be removed by proper cooling and ventilation immediately after the pellets leave the pelleting apparatus.

Pellet quality refers to resistance to crumbling and water stability. The amounts of fat, fiber, or starch in the formula can influence quality of the pelleted feed. Some ingredients, because of chemical or physical properties, do not have desirable pelleting quality and can be used only in limited quantity in pelleted feeds.

Additives that serve primarily as pelleting aids are frequently used in fish feed formulas to reduce fines and increase water stability, although research in fish feed technology has demonstrated that high-quality fish feeds can be made without binding materials by following good pelleting procedures. However, use of compounds such as hemicellulose and cellulose derivatives, lignosulfonates, bentonites, and others does allow the processor greater variation in ingredient selection and processing conditions to produce pellets of satisfactory quality.

Physical Properties and Processing Specifications

Fry Diet or Fish Starter Meal	100% to pass through 595 micron opening (U.S. Number 30 sieve).
Number 2 Pellet	0.32 cm (1/8 inch) diameter, 0.32 cm (1/8 inch) long.
Number 3 Pellet	0.32 cm (1/8 inch) diameter, 0.95-1.3 cm (3/8-1/2 inch) long.
Number 4 Pellet	0.5 cm (3/16 inch) diameter, 0.6-1.3 cm (1/4-1/2 inch) long.
Number 5 Pellet	0.6 cm (1/4 inch) diameter, 0.6-1.3 cm (1/4-1/2 inch) long.

The pelleted ration should be retained on a 0.32-cm (1/8-inch)-mesh screen when immersed in water for 10 minutes, with no more than 10 percent of the original weight being lost. This specification may be met by grinding the formula through a 0.32-cm (1/8-inch)-mesh screen after mixing, using high-pressure, high-quality (dry) steam to condition diet mixture before pelleting, cooling rapidly, and handling without undue breakage. No more than 4 percent fines should be present in bagged pellets.

EXTRUDING

Higher levels of moisture, heat, and pressure are employed in extrusion (or expansion) processing than in pelleting of fish feeds. Usually, the mixture of finely ground ingredients is conditioned with steam or water and may be precooked before entering the extruder. The mash, which contains around 25 percent moisture, is compacted and heated to

135° to 175° C under high pressure. As the material is squeezed through die holes at the end of the extruder barrel, part of the water in the superheated dough immediately vaporizes and causes expansion. The low-density extruded particles contain more water than pellets and require more drying. Heat-sensitive vitamins are usually added topically after extrusion and drying. Extruded feeds are more firmly bound due to the almost complete gelatinization of the starch and result in less fines than pellets.

Extruded or expanded fish feeds have two definite advantages over pelleted feeds: the particles float and are more resistant to disintegration in water; and a floating feed allows the fish culturist to observe the condition of the fish and the amount of food consumed. A large percentage of the catfish farmers in the United States use expanded feeds.

MOIST DIETS

Eel diets are fed in moist form. The feed, containing as much as 25 percent precooked starch, is bagged as a dry meal to which the farmer adds water and usually fish oil. A cohesive, dough-like ball is formed and is placed in wire containers in the culture facility. Other fish such as yellowtail do not accept hard feeds readily and are usually fed a mixture of dry feed and ground trash fish extruded into moist pellets.

CRUSTACEAN DIETS

Crustaceans are deliberate feeders and require diets that will remain stable in water for a much longer time than conventional fish pellets. Pregelatinized starches, alginates, carboxymethyl cellulose, and other hydrocolloidal materials with good binding properties are used in pelleting crustacean feeds. Extrusion processing is also a valuable tool in making crustacean feeds.

AQUARIUM FISH DIETS

Aquarium fishes require diets that are not only nutritious and palatable but that also float or sink slowly and are water stable. Flaked feed processed on rotary drum dryers have met these criteria. The ingredients are ground to extremely fine particle size and blended with water to form a slurry that is spread over the surface of the drum to dry in a thin sheet. The dried sheet is scraped off the drum and crumbled into flakes. The formula must contain ingredients with good colloidal properties as well as tensile strength (see Appendix B).

FEEDS OF SMALL PARTICLE SIZE

Small fish, such as bait fish, ornamental fish, or the fry of large species, may require food in small-size particles. Such foods, called meal or crumbles, are usually made by first pelleting or extruding the feed mixture and then reducing the particles to the desired size by crushing. Even though the feeds are fed as small particles, prior pelleting helps to minimize separation of formula ingredients when the feed is put into the water. Topical application of fat to the small particles also reduces leaching of micronutrients.

STORAGE OF FISH FEEDS

Fish feeds properly dried following pelleting or extruding and stored in cool and dry conditions will remain in good condition for relatively long periods. Generally, 90 days is the maximum storage time recommended for a complete fish feed stored at ambient temperature. High-moisture conditions cause mold growth. Some molds produce toxins (mycotoxins) that are detrimental to fish. Mold inhibitors may be added to fish feeds that are prepared for use in warm, humid areas. Propionic acid may be used for this purpose at a level of 0.25 percent of the ration.

Some nutrients are sensitive to oxidation and decrease in activity with storage time. Some ingredients are strongly pro-oxidative, such as fish oils, bloodmeal, or trace-mineral additives. Fish feeds should contain antioxidants to protect the oxygen-sensitive nutrients from such agents.

Ascorbic acid is the most sensitive vitamin to deterioration during storage. The half-life for ascorbic acid in pelleted fish feeds is approximately 3 months at 26° C and 50 to 90 percent relative humidity.

All fish feeds should be stored carefully, but storage time and conditions of storage are more important for complete than for supplemental feeds. Effects of nutrient deterioration, as with vitamins, will be more serious for fish that must receive all of the nutrients from the ration than for fish that have access to pond organisms.

FEEDING RECOMMENDATIONS

Efficient and economical production of warmwater fish requires use of diets formulated to meet the nutritional requirements of the species and also the development of good feeding procedures. Fish culturists face a problem other animal husbandmen do not in that uneaten or unassimilated food contaminates the environment and may be hazardous to the health of the fish. Moreover, unconsumed fish food is soon dispersed in the water and makes relatively little contribution to fish production. Feeding procedures are affected by environmental factors such as temperature and water quality, physical factors such as rate of water exchange and type of rearing facility, management factors such as frequency and rate of feeding, and type and size of fish.

FEEDING PROCEDURES

Presentation of the ration in the vicinity of the individual fish and in the particle size, shape, and texture acceptable to the species being fed is important. Small fish may travel only a few meters to accept food, and thus the ration should be made available over a wide area. Large fish will travel longer distances, but the size and number of feeding sites should be sufficient to enable all the fish to eat. Particle density must be considered since some fish may feed only on the water surface and others may feed from the bottom. Particles too large or too small to be easily consumed by the fish will not be utilized efficiently. Texture of the food is important to some fish. Fish are creatures of habit, and thus feeding them at the same time and in the same manner each day is important. Fish that accept the diet slowly should be fed slowly to reduce waste and ingredient leaching.

AMOUNT AND FREQUENCY

Amount of diet fed to fish is a fundamental consideration. Too little results in poor growth, since most of the food may be used for body maintenance. Underfeeding of fish may cause overcompetition for food, which can result in large variation in the size of individual fish at harvest. However, excessive feeding may lead to digestive and metabolic inefficiency and unconsumed food, which causes deterioration of the aquatic environment.

Frequency of feeding varies inversely with fish size. Fry-sized fish should be fed eight or more times each day. Frequency of feeding is decreased as the fish increase in size. Fingerling fish being fed for food or recreational markets can be fed one time each day unless very rapid growth is desired.

Total quantity of ration fed during each 24-hour period must not exceed the ability of the culture facility to assimilate. This amount may be as low as 20 kg/ha per day for some static water ponds. The water characteristics and amount of water exchanged or aerated may permit larger amounts to be fed.

WATER TEMPERATURE AND ENVIRONMENTAL FACTORS

All fish species have a water temperature range in which the most rapid growth and best dietary efficiency can be obtained. Feeding fish outside of this optimum temperature range may be uneconomical or even detrimental since food consumption decreases with temperature.

Composition of the ration may be altered significantly by temperature. Generally, rations that contain large amounts of animal protein ingredients are utilized more efficiently than those containing large amounts of plant ingredients when fed at low water temperatures.

Ration allowance must be adjusted frequently to compensate for changes in water temperature and quality and level of dissolved oxygen. Pond water temperature is usually at a maximum in temperate zones during late summer, when metabolite load and plankton bloom are the highest. Oxygen demand in the culture system is greatest under these conditions. Oxygen level in the water may become dangerously low on cloudy days when photosynthesis is suppressed, and thus feeding should be discontinued under these conditions.

FLOATING AND SINKING DIETS

Floating (expanded) diets enable the culturist to observe fish feeding and are used as a management aid for indirect evaluation of fish health and water quality. More experienced fish culturists may make these same evaluations with the sinking diet formulation. Catfish and other species that feed on both the surface and on the bottom will usually yield equal dietary efficiency with either floating or sinking rations.

Floating diets are used in many winter feeding programs so that the amount of food consumed can be measured more accurately. The better water stability of the floating formulation allows sufficient time for slow-eating fish to consume the diet.

PHASE FEEDING

Animal production is more profitable when using rations having optimum nutrient content. Optimum nutrient content of a diet varies with the animal's size and age and the daily average temperature of the water. In some northern climates, a 25-percent-protein diet proves sufficient for optimum fish production, but, in some southern areas, the most economical level of protein for catfish diets is 30 percent. Many warmwater fish are fed at water temperatures ranging between 0° and 35° C, although little or no growth can be expected at the lower temperatures. Therefore, there is a need to supply diets formulated to conform to the ability of the fish to utilize various nutrient levels. The nutrient content of the diet should change as water temperature changes. Fish respond to higher dietary protein percentage at higher water temperatures.

CALCULATING DIETS

When calculating diets and feed mixtures it is desirable to be able to make adjustments so the diet has a certain dry-matter content. Ways for making these adjustments are outlined in Table 9.

EXAMPLES OF TEST AND PRACTICAL DIET FORMULATIONS

Diet formulations for warmwater fishes are as varied as cost and availability of feedstuffs dictate. Combinations of feedstuffs or purified materials are usually necessary in compounding a balanced diet for the fish species being fed.

Test Diets

Examples of test, or research, diet formulas are given in Appendix A. These formulas have been found to yield satisfactory results when used as experimental diets involving vitamin or amino acid research with catfish and amino acid research with eel. The formulas may also be acceptable for use with certain other species of carnivorous fishes.

Practical Diets

Examples of the practical diet formulas given in Appendix B have been used under various conditions of water quality and water temperature and with various strains of the fish species for which the formulas are intended. These formulas are offered as examples only, and when used with proper fish cultural procedure each should perform satisfactorily.

TABLE 9 Formulas for Calculating Diets and Feed Mixtures and for Adjusting Moisture Content[a]

FROM DRY TO AS-FED

To be used in converting the amounts of ingredients of a dry diet to a wet diet having a given percent of dry matter.[b]

Formula 1

Parts of ingredient in wet diet =
(% ingredient in dry diet × % dry matter wanted in diet)/
% dry matter in ingredient.
Total the parts and add enough water to make 100 parts (or 100%).

FROM WET TO DRY

To be used in calculating the amount of an ingredient that should be contained in a dry diet if the amount required in a wet diet having a given percent of dry matter is known.

Formula 2

% of ingredient in wet diet =
(% ingredient in wet diet/% dry matter wanted in diet) ×
% dry matter in ingredient.

FROM WET TO DRY

To be used if the diet is on an as-fed basis and it is desired to change the amounts of the ingredients to a dry basis.

Formula 3

Parts on wet basis = % ingredient in wet diet ×
% dry matter of ingredient.
Perform this calculation for each ingredient; then add the products and divide each product by the sum of the products.

FROM WET TO DRY

To be used if the diet is on an as-fed basis and it is desired to compare the nutrient content of the diet with dry-basis requirements.

Formula 4

% nutrient in dry diet (total) =
% nutrient in wet diet (total)/% dry matter in diet (total).

[a] SOURCE: L. E. Harris, J. M. Asplund, and E. W. Crampton, Utah Agric. Exp. Stn. Bull. 479, 1968.
[b] The term "dry diet" means a diet calculated on a dry (moisture-free) basis; "as fed" means a diet calculated to contain the amount of dry matter as it is fed to the animal.

COMPOSITION OF FEEDS

Tables 10, 11, 12, 13, and 14 give the composition of feeds commonly used in warmwater fish diets.* Two larger compilations are available.†

NOMENCLATURE

In previous NRC nutrient requirement reports the names of the feeds gave considerable detail as to the way the feed was processed and the grade or quality designation. In this publication short names are used. A complete short feed name consists of as many as eight components. However, only enough components are used to be able to identify the feed. The components are as follows:

- Origin (or parent material)
- Species, variety, or kind
- Part eaten
- Process(es) and treatment(s) undergone before fed to animal
- Stage of maturity
- Cutting or crop
- Grade or quality designation
- Classification

Feeds of the same origin (and the same species, variety, or kind, if one of these is stated) are grouped into eight classes. The numbers and classes they designate are as follows:

1. Dry forages and roughages
2. Pasture, range plants, and forages fed green
3. Silages
4. Energy feeds
5. Protein supplements
6. Minerals
7. Vitamins
8. Additives

Feeds that in the dry state contain on the average more than 18 percent of crude fiber are classified as forages or roughages. Feeds that contain 20 percent or more of protein are classified as protein supplements. Products that contain less than 20 percent of protein and less than 18 percent crude fiber are classified as energy feeds.

Abbreviations have been devised for some of the terms in the short feed names (Table 15).

A six-digit "International Feed Number" is given for each feed. The first digit is the class of the feed. This reference number may be used as the "numerical name" of a feed when making up a diet with electronic computers. This number is also listed after each "Legal Feed Definition" in the Association of American Feed Control Officials Handbook.**

The description of how the short names are made is shown in Table 16. When written out in linear form, the names in Table 10 would appear as follows, with a comma between each component:

Feed No. 1: Clover, red, hay, s-c
Feed No. 2: Soybean, seeds, meal solv extd, 44% protein
Feed No. 3: Wheat, soft white winter, grain

The names may vary slightly in each report because changes are made as more is known about a given feed or the Association of American Feed Control Officials or the Canada Feeds Act may change the name or definition of a feed. However, if the feed name changes, the international feed number remains the same for the same feed.

Some feeds have several names. The material in parentheses after some feeds helps identify them. The reader will find

*These tables were prepared by the Subcommittee on Feed Composition, Committee on Animal Nutrition, National Research Council: Charles W. Deyoe, *Chairman*, J. R. Aitken, Joe H. Conrad, Lorin E. Harris, Paul W. Moe, R. L. Preston, Peter J. Van Soest, and the International Feedstuffs Institute, Logan, Utah.

†Publication 1684, *United States-Canadian Tables of Feed Composition*, lists about 400 feeds. Publication 1919, *Atlas of Nutritional Data on United States and Canadian Feeds*, lists about 6,150 feeds. Both are published by the National Academy of Sciences, Washington, D.C.

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cross-references in alphabetical order for some items referring to the origin of the short feed names and the analytical data.

LOCATING NAMES IN THE TABLES

To locate the name of a feed in the table of feed composition, one must know the name of the parent material (e.g., the origin of the feed) and usually the variety or kind of parent material. Parent materials are of four types: plant, animal, poultry, and fish. For a feed derived from a plant, the origin term is the name of the plant (e.g., Alfalfa, Barley, Oats). For a feed derived from animals or poultry, the origin term is the name of the animal or bird (e.g., Cattle, Chicken, Whale). For a feed of fish origin, the origin term is "Fish" followed by the species or variety (e.g., Fish, cod; Fish, menhaden).

When the specific origin of a feed derived from poultry or fish is not known, the origin term is "Poultry" or "Fish." When a specific origin of a feed derived from animals is not known, the origin term is the name of the animal product (i.e., Blood, meal). Fats or oils are listed under the term "Fats and Oils," and the various kinds of molasses or syrups are listed under "Molasses and Syrups."

DATA

The analytical data are expressed in the metric system and are on an as-fed and dry basis. Analytical data may differ in the various NRC reports because the data are updated for each report. Individual feed samples may vary widely from averages in the table. Variations are influenced by factors such as crop, variety, climate, soil, and length of storage. Therefore, the values given should be used with judgment, to be related, if possible, to analyses about the feed on hand for critical nutrients.

See Table 17 for weight-unit conversion factors and Table 18 for weight equivalents.

ENERGY VALUES OF FEEDS

Metabolizable energy (ME) values for fish were not available; therefore, those for poultry are given when available.

Gross energy values for feeds were calculated by the formula of Nehring and Haenlein* when specific values were missing:

Gross energy (kcal/kg) =
$$[5.72(\text{CP}\%) + 9.50\ (\text{EE}\%) + 4.79(\text{CF}\%) + 4.03(\text{NFE}\%) \times 1{,}000]/100$$

where CP = crude protein; EE = ether extract; CF = crude fiber; and NFE = nitrogen free extract.

CAROTENE CONVERSION

International standards for vitamin A are based on the utilization of vitamin A and beta-carotene by the rat. Fish probably do not convert carotene to vitamin A in the same ratio as rats. However, values obtained for the rat may be useful in estimating total vitamin A activity in total diets.

International standards for vitamin A activity as related to vitamin A and beta-carotene are as follows:

1 IU of vitamin A = 1 USP unit
= vitamin A activity of 0.300 μg of crystalline vitamin A alcohol, which corresponds to 0.344 μg of vitamin A acetate or 0.550 μg of vitamin A palmitate

Beta-carotene is the standard for provitamin A.

1 IU of vitamin A = 0.6 μg of beta-carotene
1 μg of beta-carotene = 1667 IU of vitamin A

Data for plant and animal feeds in Table 10 have been converted to vitamin A equivalent (mg/kg).

*K. Nehring and G. F. W. Haenlein. Feed evaluation and ration calculation based on net energy fat. J. Anim. Sci. 36:949-996, 1973.

TABLES

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
	ALFALFA. *Medicago sativa*												
001	—meal dehy, 15% protein	1-00-022	91	1589	3895	15.4	2.3	25.9	39.0	8.8	1.27	9.5	0.118
002			*100*	*1741*	*4280*	*16.9*	*2.5*	*28.3*	*42.7*	*9.6*	*1.39*	*10.5*	*0.129*
003	—meal dehy, 17% protein	1-00-023	92	1496	3939	17.5	2.7	24.4	38.0	9.7	1.33	9.0	0.149
004			*100*	*1622*	*4280*	*18.9*	*2.9*	*26.4*	*41.2*	*10.5*	*1.44*	*9.8*	*0.161*
005	—meal dehy, 20% protein	1-00-024	91	1611	3915	20.2	3.2	20.4	37.1	10.4	1.56	12.4	0.134
006			*100*	*1763*	*4300*	*22.1*	*3.5*	*22.4*	*40.6*	*11.4*	*1.70*	*13.6*	*0.147*
007	—meal dehy, 22% protein	1-07-851	93	1657	4068	22.0	3.9	18.6	38.1	10.2	1.63	9.8	0.165
008			*100*	*1787*	*4374*	*23.7*	*4.2*	*20.1*	*41.1*	*11.0*	*1.76*	*10.5*	*0.178*
	BARLEY. *Hordeum vulgare*												
009	—grain	4-00-549	88	2460	3537	12.2	1.9	5.0	66.6	2.3	0.04	8.0	0.044
010			*100*	*2798*	*4019*	*13.9*	*2.2*	*5.6*	*75.7*	*2.6*	*0.05*	*9.1*	*0.050*
011	—grain, Pacific Coast	4-07-939	90	2481	3819	9.6	1.7	6.3	69.3	2.8	0.05	8.2	—
012			*100*	*2768*	*4243*	*10.7*	*1.9*	*7.0*	*77.3*	*3.1*	*0.05*	*9.1*	—
013	—malt sprouts, dehy	5-00-545	92	1418	4079	26.1	1.3	14.5	43.8	6.4	0.21	—	—
014			*100*	*1538*	*4434*	*28.4*	*1.5*	*15.7*	*47.5*	*7.0*	*0.23*	—	—
	BEET, SUGAR. *Beta vulgaris, saccharifera* —molasses—see Molasses, beet												
015	—pulp, dehy	4-00-669	90	657	3812	8.6	0.5	18.4	58.4	4.6	0.65	12.4	—
016			*100*	*727*	*4236*	*9.5*	*0.5*	*20.3*	*64.5*	*5.1*	*0.72*	*13.8*	—
	BLOOD. Animal												
017	—meal	5-00-380	92	2733	5225	75.3	1.6	1.0	8.5	5.4	0.27	13.2	—
018			*100*	*2976*	*5679*	*82.0*	*1.8*	*1.1*	*9.2*	*5.9*	*0.30*	*14.4*	—
019	—meal spray dehy	5-00-381	86	2565	4753	72.2	6.2	1.3	−1.3	7.2	1.64	7.6	—
020			*100*	*2998*	*5527*	*84.4*	*7.2*	*1.6*	*−1.5*	*8.4*	*1.92*	*8.8*	—
	BONE. Animal												
021	—meal steamed	6-00-400	97	—	—	11.2	9.2	1.6	−5.0	80.2	31.39	12.0	—
022			*100*	—	—	*11.5*	*9.4*	*1.7*	*−5.1*	*82.6*	*32.34*	*12.3*	—
023	—phosphate	6-00-406	99	—	—	0.4	0.3	—	—	86.2	27.90	—	—
024			*100*	—	—	*0.4*	*0.3*	—	—	*87.3*	*28.30*	—	—
	BREWERS.												
025	—grains, dehy	5-02-141	92	2186	4612	25.0	6.8	14.3	41.9	3.8	0.30	21.6	0.065
026			*100*	*2377*	*5013*	*27.2*	*7.4*	*15.6*	*45.6*	*4.2*	*0.32*	*23.5*	*0.071*
	BUTTERMILK. *Bos taurus*												
027	—condensed	5-01-159	29	—	1333	10.8	2.4	0.1	12.4	3.7	0.44	—	—
028			*100*	—	*4595*	*36.9*	*8.1*	*0.3*	*42.2*	*12.5*	*1.51*	—	—

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinosital (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
001	0.027	0.28	28.1	0.22	19.6	—	0.26	1588	—	—	42.0	20.9	37.5	6.33	10.7	3.0	—	82.7	9.68
002	*0.030*	*0.30*	*30.8*	*0.24*	*21.4*	—	*0.28*	*1739*	—	—	*46.0*	*22.9*	*41.2*	*6.94*	*11.7*	*3.3*	—	*90.6*	*10.61*
003	0.042	0.29	30.9	0.24	19.5	—	0.30	1405	6.27	—	39.4	29.4	60.4	8.02	13.2	3.4	—	124.3	8.63
004	*0.046*	*0.32*	*33.5*	*0.26*	*21.1*	—	*0.33*	*1523*	*6.81*	—	*42.7*	*31.8*	*65.6*	*8.70*	*14.4*	*3.7*	—	*134.8*	*9.36*
005	0.038	0.33	45.9	0.28	20.1	—	0.33	1425	—	—	48.3	35.7	79.1	9.11	14.7	5.6	10.9	158.9	14.53
006	*0.042*	*0.36*	*50.2*	*0.30*	*22.0*	—	*0.36*	*1559*	—	—	*52.8*	*39.1*	*86.9*	*9.97*	*16.1*	*6.1*	*12.0*	*173.8*	*15.90*
007	0.036	0.32	36.4	0.30	19.5	—	0.33	1526	—	—	50.2	39.0	117.6	8.27	17.6	5.9	11.1	221.2	11.64
008	*0.038*	*0.34*	*39.2*	*0.33*	*21.0*	—	*0.36*	*1646*	—	—	*54.1*	*42.0*	*126.5*	*8.92*	*19.0*	*6.3*	*12.0*	*238.5*	*12.55*
009	0.008	0.14	16.1	0.33	45.2	—	0.14	902	—	—	84.9	8.2	—	6.56	1.6	4.4	—	15.8	—
010	*0.009*	*0.15*	*18.3*	*0.37*	*51.4*	—	*0.16*	*1026*	—	—	*96.5*	*9.3*	—	*7.46*	*1.8*	*5.0*	—	*18.0*	—
011	0.010	0.12	16.2	0.34	15.4	—	0.15	998	—	—	47.8	7.1	3.9	2.92	1.6	4.2	—	21.0	—
012	*0.012*	*0.13*	*18.0*	*0.38*	*17.1*	—	*0.17*	*1114*	—	—	*53.3*	*7.9*	*4.2*	*3.26*	*1.7*	*4.7*	—	*23.5*	—
013	—	0.18	31.8	0.73	—	—	—	1579	—	—	52.0	8.7	1.4	—	6.7	5.0	—	20.6	—
014	—	*0.20*	*34.5*	*0.79*	—	—	—	*1713*	—	—	*56.4*	*9.4*	*1.6*	—	*7.3*	*5.4*	—	*22.4*	—
015	0.030	0.27	34.6	0.09	0.7	—	—	814	—	—	16.7	1.4	—	—	0.8	0.4	—	—	—
016	*0.033*	*0.30*	*38.3*	*0.10*	*0.8*	—	—	*900*	—	—	*18.5*	*1.5*	—	—	*0.8*	*0.4*	—	—	—
017	0.307	0.22	5.3	0.26	4.4	—	0.08	727	—	—	31.2	2.9	—	4.42	2.2	0.4	44.2	—	—
018	*0.334*	*0.24*	*5.8*	*0.29*	*4.8*	—	*0.09*	*792*	—	—	*34.0*	*3.1*	—	*4.81*	*2.3*	*0.4*	*48.1*	—	—
019	0.256	0.04	5.9	0.45	—	—	—	260	—	—	26.6	4.9	0.1	—	3.9	0.4	—	—	—
020	*0.299*	*0.04*	*6.9*	*0.52*	—	—	—	*304*	—	—	*31.1*	*5.7*	*0.1*	—	*4.5*	*0.5*	—	—	—
021	0.069	0.57	33.2	12.91	326.6	—	—	—	—	—	4.4	2.2	—	—	1.0	0.9	—	—	—
022	*0.071*	*0.59*	*34.2*	*13.30*	*336.4*	—	—	—	—	—	*4.5*	*2.3*	—	—	*1.0*	*0.9*	—	—	—
023	—	—	—	11.16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
024	—	—	—	*11.31*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
025	0.025	0.16	37.8	0.53	27.2	—	0.96	1669	0.22	—	43.0	8.1	—	0.66	1.3	0.5	—	25.8	—
026	*0.027*	*0.17*	*41.1*	*0.58*	*29.6*	—	*1.05*	*1815*	*0.24*	—	*46.8*	*8.8*	—	*0.72*	*1.4*	*0.6*	—	*28.1*	—
027	—	0.19	—	0.26	—	—	—	—	—	—	—	—	—	—	12.6	—	—	—	—
028	—	*0.65*	—	*0.89*	—	—	—	—	—	—	—	—	—	—	*42.8*	—	—	—	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
			As-Fed and Dry Basis (Moisture Free)										
029	—dehy	5-01-160	92	2767	3663	31.5	4.7	0.4	46.4	9.0	1.31	—	—
030			*100*	*3007*	3981	*34.3*	*5.1*	*0.4*	*50.4*	*9.8*	*1.42*	—	—
031	CALCIUM CARBONATE.	6-01-071	99	—	—	—	—	—	—	95.4	38.00	24.0	—
032	Precipitated, $CaCO_3$		*100*	—	—	—	—	—	—	*95.8*	*38.10*	*24.1*	—
	CASEIN.												
033	—dehy	5-01-162	90	4140	4935	82.0	0.7	0.2	4.6	2.9	0.41	4.0	—
034			*100*	*4578*	*5480*	*90.7*	*0.8*	*0.2*	*5.1*	*3.2*	*0.45*	*4.4*	—
	CITRUS. *Citrus* spp.												
035	—pulp wo fines, dehy (Dried	4-01-237	90	1325	3789	6.3	3.6	12.8	62.0	5.9	1.87	5.7	—
036	citrus pulp)		*100*	*1465*	*4211*	*6.9*	*4.0*	*14.1*	*68.5*	*6.5*	*2.07*	*6.3*	—
	COCONUT. *Cocos nucifera*												
037	—meats, meal mech extd	5-01-572	93	1491	4268	21.2	6.5	11.5	46.9	6.8	0.22	14.1	—
038	(Copra meal)		*100*	*1605*	*4589*	*22.8*	*6.9*	*12.4*	*50.5*	*7.3*	*0.22*	*15.2*	—
039	—meats, meal solv extd	5-01-573	92	1596	4124	21.3	4.1	13.6	46.1	6.6	0.18	9.5	—
040	(Copra meal)		*100*	*1743*	*4482*	*23.2*	*4.4*	*14.8*	*50.3*	*7.2*	*0.19*	*10.4*	—
	CORN. *Zea mays*												
041	—distillers grains w sol-	5-02-843	92	2522	4542	27.1	9.9	9.4	41.2	4.4	0.14	50.8	—
042	ubles, dehy		*100*	*2742*	*4937*	*29.5*	*10.7*	*10.2*	*44.8*	*4.8*	*0.16*	*55.2*	—
043	—distillers solubles, dehy	5-02-844	92	2880	3827	27.3	8.4	5.2	44.2	7.3	0.30	82.4	0.108
044			*100*	*3118*	*4160*	*29.5*	*9.1*	*5.6*	*47.8*	*7.9*	*0.33*	*89.2*	*0.117*
045	—germ, meal wet milled	5-02-898	90	—	—	20.0	—	12.0	—	—	—	—	—
046	solv extd		*100*	—	—	*22.2*	—	*13.3*	—	—	—	—	—
047	—gluten, meal	5-02-900	91	2952	4668	43.1	2.2	4.5	38.3	3.3	0.15	28.4	—
048			*100*	*3231*	*5130*	*47.2*	*2.4*	*5.0*	*41.9*	*3.6*	*0.16*	*31.1*	—
049	—hominy feed	4-02-887	90	2827	4246	10.9	7.3	5.0	63.7	2.7	0.05	13.6	—
050			*100*	*3157*	*4718*	*12.2*	*8.2*	*5.6*	*71.1*	*3.0*	*0.05*	*15.2*	—
	CORN, DENT YELLOW. *Zea mays, indentata*												
051	—grain	4-02-935	88	3364	3871	9.6	3.9	2.1	70.8	1.3	0.03	3.2	—
052			*100*	*3838*	*4398*	*10.9*	*4.5*	*2.4*	*80.8*	*1.4*	*0.03*	*3.6*	—
	CORN, FLINT. *Zea mays, indurata*												
053	—grain	4-02-948	89	—	3945	9.9	4.3	1.9	70.9	1.5	—	11.5	—
054			*100*	—	*4432*	*11.1*	*4.9*	*2.1*	*80.2*	*1.7*	—	*13.0*	—
	COTTON. *Gossypium* spp.												
055	—seeds, meal mech extd,	5-01-617	93	2232	4640	40.8	4.6	11.2	30.0	6.2	0.20	18.1	—
056	41% protein		*100*	*2405*	*4989*	*44.0*	*5.0*	*12.1*	*32.3*	*6.6*	*0.22*	*19.5*	—

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (µg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
029	0.001	0.48	3.4	0.93	—	—	0.29	1685	0.40	—	8.6	36.0	7.6	2.41	31.0	3.4	19.4	6.2	—
030	*0.001*	*0.52*	*3.7*	*1.01*	—	—	*0.32*	*1831*	*0.43*	—	*9.3*	*39.1*	*8.3*	*2.62*	*33.7*	*3.7*	*21.1*	*6.8*	—
031	0.034	0.50	219.0	—	—	—	—	—	—	—	—	0.6	—	—	—	—	—	—	—
032	*0.034*	*0.50*	*280.0*	—	—	—	—	—	—	—	—	*0.7*	—	—	—	—	—	—	—
033	—	—	4.2	0.84	—	—	0.04	205	0.41	—	1.3	2.6	—	0.42	1.5	0.4	—	—	—
034	—	—	*4.7*	*0.93*	—	—	*0.05*	*227*	*0.56*	—	*1.5*	*2.9*	—	*0.47*	*1.7*	*0.5*	—	—	—
035	0.015	0.15	6.5	0.12	13.0	—	—	800	—	—	22.0	13.7	0.1	—	2.3	1.5	—	—	—
036	*0.017*	*0.16*	*7.2*	*0.13*	*14.4*	—	—	*884*	—	—	*24.4*	*15.1*	*0.1*	—	*2.5*	*1.6*	—	—	—
037	0.132	0.31	65.6	0.62	—	—	—	1013	1.39	—	24.6	6.2	—	—	3.2	0.8	—	—	—
038	*0.142*	*0.33*	*70.6*	*0.67*	—	—	—	*1091*	*1.50*	—	*26.5*	*6.6*	—	—	*3.5*	*0.8*	—	—	—
039	0.069	0.36	65.7	0.60	—	—	—	1040	—	—	25.6	6.4	—	4.38	3.3	0.7	—	—	—
040	*0.075*	*0.39*	*71.8*	*0.66*	—	—	—	*1136*	—	—	*27.9*	*7.0*	—	*4.78*	*3.6*	*0.7*	—	—	—
041	0.051	0.14	22.1	0.72	—	—	0.78	2584	0.82	—	73.0	14.5	1.8	2.21	9.3	2.9	—	40.0	—
042	*0.056*	*0.15*	*24.1*	*0.79*	—	—	*0.85*	*2809*	*0.89*	—	*79.3*	*15.8*	*2.0*	*2.40*	*10.1*	*3.2*	—	*43.5*	—
043	0.057	0.63	73.6	1.23	84.5	—	1.41	4808	1.11	—	116.9	23.5	0.4	8.81	21.2	6.7	28.0	45.6	—
044	*0.061*	*0.69*	*79.7*	*1.34*	*91.5*	—	*1.53*	*5206*	*1.21*	—	*126.6*	*25.5*	*0.4*	*9.54*	*23.0*	*7.3*	*30.3*	*49.4*	—
045	—	—	—	—	100.0	—	0.22	—	—	—	—	—	—	—	—	—	—	—	—
046	—	—	—	—	*111.1*	—	*0.24*	—	—	—	—	—	—	—	—	—	—	—	—
047	0.039	0.05	7.3	0.47	—	—	0.18	370	0.22	—	50.3	9.9	8.2	8.01	1.4	0.2	—	34.0	—
048	*0.043*	*0.05*	*8.0*	*0.51*	—	—	*0.19*	*405*	*0.24*	—	*55.0*	*10.8*	*9.0*	*8.77*	*1.6*	*0.2*	—	*37.2*	—
049	0.007	0.23	14.4	0.53	—	—	0.13	988	—	—	47.0	7.5	4.6	10.87	2.1	7.8	—	—	—
050	*0.008*	*0.26*	*16.1*	*0.59*	—	—	*0.14*	*1104*	—	—	*52.5*	*8.4*	*5.1*	*12.14*	*2.3*	*8.8*	—	—	—
051	0.002	0.12	4.9	0.27	18.2	—	0.06	534	—	500	29.9	6.6	1.1	5.16	1.3	2.1	—	22.5	—
052	*0.003*	*0.14*	*5.6*	*0.30*	*20.8*	—	*0.07*	*609*	—	*568*	*34.2*	*7.5*	*1.2*	*5.89*	*1.5*	*2.3*	—	*25.7*	—
053	0.003	—	7.0	0.27	—	—	—	—	—	—	15.8	—	—	—	—	—	—	—	—
054	*0.003*	—	*7.9*	*0.31*	—	—	—	—	—	—	*17.9*	—	—	—	—	—	—	—	—
055	0.013	0.53	23.0	1.01	—	—	0.77	2781	3.42	—	32.4	9.8	0.1	5.37	4.8	6.6	—	32.4	—
056	*0.014*	*0.57*	*24.8*	*1.09*	—	—	*0.83*	*2997*	*3.68*	—	*34.9*	*10.6*	*0.1*	*5.79*	*5.2*	*7.2*	—	*34.9*	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
057	—seeds, meal prepressed	5-07-872	90	2398	4204	41.4	0.6	13.6	27.9	6.4	0.15	17.8	—
058	solv extd, 41% protein		*100*	*2667*	*4671*	*46.1*	*0.6*	*15.1*	*31.1*	*7.1*	*0.17*	*19.8*	—
059	—seeds, meal solv extd,	5-01-621	91	1883	4320	41.3	2.3	12.4	29.0	6.6	0.18	20.8	—
060	41% protein		*100*	*2059*	*4748*	*45.2*	*2.5*	*13.5*	*31.7*	*7.2*	*0.19*	*22.8*	—
061	—seeds wo hulls, meal pre-	5-07-874	93	2172	4434	50.0	1.1	8.2	26.8	6.9	0.19	18.0	—
062	pressed solv extd, 50% protein		*100*	*2335*	*4768*	*53.7*	*1.2*	*8.8*	*28.8*	*7.4*	*0.20*	*19.4*	—
	CRAB. *Callinecies sapidus: Cancer* spp. *paralithodes camschatica*												
063	—cannery residue, meal	5-01-663	93	1842	2799	31.2	2.0	10.7	7.4	41.3	14.91	32.8	0.560
064	(Crab meal)		*100*	*1988*	*3010*	*33.7*	*2.2*	*11.5*	*8.0*	*44.6*	*16.09*	*35.5*	*0.604*
	DEFLUORINATED PHOSPHATE. see Phosphate												
065	DICALCIUM PHOSPHATE.	6-01-080	97	—	—	—	—	—	—	89.0	22.99	6.0	—
066	$CaHPO_4 \cdot 2H_2O$		*100*	—	—	—	—	—	—	*91.7*	*23.70*	*6.2*	—
	DISTILLERS GRAINS. see Corn												
	FATS AND OILS.												
067	—fat, animal—poultry	4-00-409	100	7434	—	—	99.4	—	—	—	—	—	—
068			*100*	*7471*	—	—	*99.9*	—	—	—	—	—	—
	FEATHERS. see Poultry												
	FISH, ALEWIFE. *Pomolobus pseudoharengus*												
069	—meal mech extd	5-09-830	90	3500	4660	65.7	12.8	1.0	−4.0	14.6	5.20	18.0	—
070			*100*	*3889*	*5177*	*73.0*	*14.2*	*1.1*	*−4.5*	*16.2*	*5.78*	*20.0*	—
071	—whole, fresh	5-07-964	26	—	1290	19.4	4.9	—	—	1.5	—	—	—
072			*100*	—	*4961*	*75.8*	*19.1*	—	—	*5.9*	—	—	—
	FISH, ANCHOVY. *Engraulis ringen*												
073	—meal mech extd	5-01-985	92	2632	4609	65.7	4.1	1.0	6.2	15.1	3.76	9.1	0.864
074			*100*	*2859*	*5010*	*71.3*	*4.5*	*1.1*	*6.7*	*16.4*	*4.08*	*9.9*	*0.938*
	FISH, CARP. *Cyprinus carpio*												
075	—meal mech extd	5-01-987	90	—	—	52.7	—	—	—	—	—	—	—
076			*100*	—	—	*58.6*	—	—	—	—	—	—	—
077	—whole, fresh	5-01-986	29	—	1502	19.0	7.6	—	—	2.3	0.06	—	—
078			*100*	—	*5108*	*66.7*	*26.8*	—	—	*7.9*	*0.23*	—	—
	FISH, CATFISH. *Ictalurus* spp.												
079	—boiled	5-09-833	40	—	—	11.1	—	—	—	—	—	3.0	—

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B12 (µg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
057	0.010	0.40	20.0	0.97	62.3	—	0.55	2933	—	—	40.3	7.0	—	—	4.0	3.3	—	—	—
058	*0.012*	*0.44*	*22.2*	*1.08*	*69.3*	—	*0.61*	*3263*	—	—	*44.8*	*7.8*	—	—	*4.4*	*3.7*	—	—	—
059	0.022	0.57	20.8	1.11	—	—	0.61	2798	2.79	—	41.3	14.1	—	6.40	4.9	6.3	—	14.2	—
060	*0.024*	*0.62*	*22.8*	*1.21*	—	—	*0.66*	*3058*	*3.06*	—	*45.1*	*15.4*	—	*6.99*	*5.3*	*6.9*	—	*15.5*	—
061	0.011	0.47	23.0	1.20	73.8	—	0.10	3000	—	—	45.0	12.4	—	7.04	5.0	—	—	15.1	—
062	*0.012*	*0.50*	*24.8*	*1.29*	*79.4*	—	*0.11*	*3226*	—	—	*48.4*	*13.4*	—	*7.57*	*5.4*	—	—	*16.2*	—
063	0.306	0.88	133.4	1.56	—	—	0.07	2017	—	—	45.2	6.5	—	6.65	6.2	0.4	329.9	—	—
064	*0.330*	*0.95*	*144.0*	*1.69*	—	—	*0.07*	*2177*	—	—	*48.8*	*7.0*	—	*7.18*	*6.7*	*0.5*	*356.2*	—	—
065	0.128	—	148.6	18.27	26.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
066	*0.132*	—	*153.2*	*18.84*	*27.6*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
067	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.9	—
068	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*7.9*	—
069	0.062	0.15	20.0	2.90	100.0	—	—	4230	—	—	34.0	10.0	—	—	3.7	0.1	284.0	—	—
070	*0.069*	*0.17*	*22.2*	*3.22*	*111.1*	—	—	*4700*	—	—	*37.8*	*11.1*	—	—	*4.1*	*0.1*	*315.6*	—	—
071	—	—	—	0.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
072	—	—	—	*0.85*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
073	0.021	0.24	10.8	2.48	105.7	—	0.20	3886	—	—	77.6	11.3	—	4.65	7.0	0.5	195.9	4.5	—
074	*0.023*	*0.26*	*11.7*	*2.70*	*114.8*	—	*0.21*	*4221*	—	—	*84.3*	*12.3*	—	*5.05*	*7.6*	*0.5*	*212.8*	*4.9*	—
075	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
076	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
077	0.001	—	—	0.32	—	13.0	—	—	—	—	19.3	—	2.2	—	0.5	0.1	—	—	—
078	*0.004*	—	—	*1.14*	—	*45.0*	—	—	—	—	*67.6*	—	*7.7*	—	*1.8*	*0.5*	—	—	—
079	0.020	0.50	6.0	0.97	36.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
080			*100*	—	—	*27.8*	—	—	—	—	—	*7.5*	—
081	—cuttings, fresh	5-09-832	42	—	—	11.5	—	—	—	—	2.35	3.0	—
082			*100*	—	—	*27.2*	—	—	—	—	*5.57*	*7.1*	—
083	—meal mech extd	5-09-835	94	—	—	55.3	—	—	—	—	7.77	27.7	—
084			*100*	—	—	*58.8*	—	—	—	—	*8.27*	*29.5*	—
085	—whole, fresh	5-07-965	22	—	1030	17.6	3.1	—	—	1.3	—	—	—
086			*100*	—	*4682*	*80.0*	*14.1*	—	—	*5.9*	—	—	—
	FISH, HERRING. *Clupea harengus, harengus; Clupea harengus, pallasi*												
087	—meal mech extd	5-02-000	92	3265	4927	72.2	8.5	0.7	0.0	10.5	2.17	5.9	6.695
088			*100*	*3555*	*5355*	*78.6*	*9.2*	*0.8*	*0.0*	*11.5*	*2.36*	*6.4*	*7.288*
	FISH, MENHADEN. *Brevoortia tyrannus*												
089	—meal mech extd	5-02-009	92	2829	4416	61.1	9.7	0.8	0.8	19.1	5.13	10.8	1.090
090			*100*	*3091*	*4800*	*66.7*	*10.6*	*0.9*	*0.9*	*20.9*	*5.61*	*11.8*	*1.191*
	FISH, SALMON. *Oncorhynchus* spp., *Salmo* spp.												
091	—meal mech extd	5-02-012	93	—	4669	61.5	10.8	0.3	2.5	17.9	5.48	11.9	—
092			*100*	—	*5020*	*66.1*	*11.6*	*0.3*	*2.7*	*19.2*	*5.88*	*12.8*	—
	FISH, SARDINE. *Clupea* spp., *Sardinops* spp.												
093	—meal mech extd	5-02-015	93	2897	4494	65.3	5.0	1.0	6.1	15.8	4.61	20.2	—
094			*100*	*3109*	*4832*	*70.0*	*5.4*	*1.1*	*6.5*	*17.0*	*4.95*	*21.7*	—
	FISH, TUNA. *Thunnus thynnus, Thunnus albacarea*												
095	—meal mech extd	5-02-023	93	3057	4248	59.4	7.0	0.8	3.6	22.2	8.03	10.3	—
096			*100*	*3287*	*4568*	*63.9*	*7.5*	*0.9*	*3.9*	*23.9*	*8.63*	*11.0*	—
	FISH, WHITE. Gadidae (family), Lophiidae (family) Rajidae (family)												
097	—meal mech extd	5-02-025	91	2581	3786	61.9	4.3	0.7	0.5	23.7	7.35	5.4	—
098			*100*	*2832*	*4160*	*67.9*	*4.7*	*0.8*	*0.6*	*26.0*	*8.06*	*5.9*	—
	FISH.												
099	—livers, meal mech extd	5-01-968	93	—	5220	62.8	17.3	1.2	5.4	6.1	—	—	—
100			*100*	—	*5935*	*67.7*	*18.6*	*1.3*	*5.8*	*6.6*	—	—	—
101	—solubles, condensed	5-01-969	50	1427	2422	28.9	5.1	0.4	7.1	8.9	0.34	42.7	1.108
102			*100*	*2831*	*4844*	*57.3*	*10.1*	*0.8*	*14.1*	*17.7*	*0.68*	*84.7*	*2.198*
103	—solubles, dehy	5-01-971	92	2395	4306	62.4	6.9	1.6	8.4	12.9	1.25	—	—

Line Number	As-Fed and Dry Basis (Moisture Free) Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
080	*0.050*	*1.25*	*15.0*	*2.43*	*90.2*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
081	0.004	0.05	4.5	1.08	28.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
082	*0.009*	*0.12*	*10.6*	*2.55*	*67.9*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
083	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
084	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
085	0.000	—	—	—	—	—	—	—	—	—	17.0	—	—	—	0.3	0.4	—	—	—
086	*0.002*	—	—	—	—	—	—	—	—	—	*77.3*	—	—	—	*1.4*	*1.8*	—	—	—
087	0.014	0.14	4.7	1.64	130.5	—	0.47	5299	2.37	710	91.8	17.2	—	4.77	9.6	0.3	403.3	22.1	2.16
088	*0.015*	*0.15*	*5.1*	*1.79*	*142.1*	—	*0.51*	*5769*	*2.58*	*772*	*99.9*	*18.7*	—	*5.19*	*10.4*	*0.4*	*439.1*	*24.0*	*2.35*
089	0.046	0.14	33.2	2.90	148.2	—	0.18	3111	—	—	54.5	8.8	—	4.66	4.8	0.6	117.2	12.0	—
090	*0.050*	*0.15*	*36.3*	*3.17*	*161.9*	—	*0.20*	*3398*	—	—	*59.6*	*9.6*	—	*5.09*	*5.2*	*0.6*	*128.0*	*13.1*	—
091	0.018	—	8.0	3.46	—	—	—	2783	—	—	25.0	6.8	—	—	5.7	0.9	—	—	—
092	*0.019*	—	*8.5*	*3.72*	—	—	—	*2990*	—	—	*26.8*	*7.4*	—	—	*6.2*	*0.9*	—	—	—
093	0.030	0.10	23.2	2.68	—	—	0.10	3279	—	—	75.0	11.0	—	—	5.4	0.3	238.2	—	—
094	*0.032*	*0.11*	*24.9*	*2.88*	—	—	*0.11*	*3518*	—	—	*80.5*	*11.8*	—	—	*5.8*	*0.3*	*255.5*	—	—
095	0.036	0.21	8.5	4.28	211.2	—	—	—	—	—	144.3	—	—	—	6.8	—	306.5	—	—
096	*0.039*	*0.22*	*9.1*	*4.60*	*227.2*	—	—	—	—	—	*155.2*	—	—	—	*7.3*	—	*329.7*	—	—
097	0.012	0.22	13.0	3.58	79.3	—	0.08	5028	—	—	61.7	9.6	—	5.91	9.3	3.9	89.5	8.9	—
098	*0.013*	*0.24*	*14.3*	*3.93*	*87.0*	—	*0.09*	*5516*	—	—	*67.7*	*10.6*	—	*6.49*	*10.2*	*4.2*	*98.1*	*9.8*	—
099	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
101	0.024	0.02	11.7	0.62	34.1	—	0.14	3405	—	—	153.8	32.3	0.6	12.14	11.4	4.4	275.2	—	—
102	*0.047*	*0.04*	*23.3*	*1.23*	*67.6*	—	*0.27*	*6757*	—	—	*305.1*	*64.0*	*1.3*	*24.08*	*22.6*	*8.8*	*546.0*	—	—
103	—	—	50.1	1.96	76.2	—	0.26	5732	—	—	261.8	50.1	—	23.87	11.9	7.9	324.8	6.0	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

			As-Fed and Dry Basis (Moisture Free)										
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
104			100	2597	4680	67.6	7.5	1.7	9.1	14.0	1.36	—	—
	FLAX. *Linum usitatissimum*												
105	—seeds, meal solv extd	5-02-045	91	1520	4455	34.3	5.6	8.7	36.2	5.8	0.39	26.5	0.066
106	(Linseed meal)		100	1676	4676	37.9	6.2	9.6	39.9	6.4	0.43	29.2	0.073
107	—seeds, meal solv extd	5-02-048	90	1412	4158	34.9	1.6	8.9	38.7	5.7	0.39	25.6	—
108	(Linseed meal)		100	1571	4620	38.9	1.8	9.9	43.1	6.4	0.43	28.5	—
	GRAINS.												
109	—distillers grains, dehy	5-02-144	93	—	—	27.4	7.4	12.8	43.4	1.6	0.14	47.9	—
110			100	—	—	29.6	8.0	13.8	46.9	1.7	0.15	51.7	—
	LIMESTONE.												
111	—grnd	6-02-632	100	—	—	—	—	—	—	96.3	36.03	—	—
112			100	—	—	—	—	—	—	96.4	36.07	—	—
	LINSEED. see Flax												
	LIVER. Animal												
113	—meal dehy	5-00-389	93	—	5499	66.5	15.7	1.4	2.9	6.3	0.56	89.5	—
114			100	—	5913	71.7	17.0	1.5	3.1	6.8	0.61	96.5	—
	MEAT. Animal												
115	—meal rendered	5-00-385	93	2088	3781	54.3	8.2	2.4	2.9	25.0	7.96	9.8	—
116			100	2247	4066	58.5	8.9	2.6	3.1	26.9	8.56	10.5	—
117	—w blood, meal tankage	5-00-386	92	2683	4526	59.5	9.0	2.2	−0.3	21.7	5.80	38.7	—
118	rendered		100	2918	4920	64.7	9.7	2.4	−0.4	23.6	6.31	42.1	—
119	—w bone, meal rendered	5-00-388	93	2142	3850	50.5	9.9	2.0	2.2	28.4	10.16	1.5	1.313
120			100	2304	4140	54.3	10.6	2.2	2.4	30.5	10.92	1.6	1.412
	MILK. *Bos taurus*												
121	—dehy	5-01-167	96	—	4908	25.1	26.5	0.2	38.5	5.4	0.91	0.9	—
122			100	—	5113	26.3	27.6	0.2	40.2	5.7	0.95	0.9	—
123	—skimmed dehy	5-01-175	94	2537	3463	33.5	0.9	0.3	51.0	8.1	1.28	11.6	—
124			100	2708	3684	35.7	0.9	0.3	54.4	8.6	1.37	12.4	—
	MILLET, FOXTAIL. *Setaria italica*												
125	—grain	4-03-102	89	—	3930	12.1	4.1	8.3	61.1	3.6	—	—	—
126			100	—	4416	13.5	4.6	9.3	68.5	4.0	—	—	—
	MOLASSES.												
127	—beet, sugar, molasses mt	4-00-668	78	1870	—	6.0	0.1	—	62.4	8.7	0.12	17.2	—
128	48% invert sugar mt 79.5 degrees brix		100	2390	—	7.7	0.2	—	79.7	11.2	0.15	22.0	—
129	—sugarcane, molasses, dehy	4-04-695	90	1966	3686	8.4	0.9	4.5	65.3	11.1	0.79	65.5	—
130			100	2180	4096	9.3	1.0	5.0	72.3	12.3	0.87	72.8	—

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
104	—	—	54.3	2.13	82.6	—	0.28	6216	—	—	283.9	54.3	—	25.88	13.0	8.6	352.2	6.5	—
105	0.018	0.58	39.5	0.85	32.9	—	0.33	1753	—	—	38.1	14.0	0.1	5.49	3.2	4.0	—	7.8	—
106	0.020	0.64	43.5	0.93	36.3	—	0.36	1933	—	—	42.0	5.5	0.1	6.05	3.5	4.4	—	8.6	—
107	0.032	0.60	37.6	0.81	—	—	—	1353	—	—	29.1	14.7	—	—	2.8	7.7	—	16.2	—
108	0.035	0.67	41.8	0.90	—	—	—	1506	—	—	32.4	16.4	—	—	3.1	8.6	—	18.0	—
109	0.026	0.10	35.0	0.40	—	—	—	—	—	—	46.8	11.6	—	—	3.8	2.5	—	—	—
110	0.028	0.10	37.8	0.43	—	—	—	—	—	—	50.5	12.5	—	—	4.1	2.6	—	—	—
111	0.349	2.06	269.3	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
112	0.350	2.06	269.6	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
113	0.063	—	8.8	1.26	—	—	0.02	11389	5.56	2375	205.3	29.2	—	—	36.3	0.2	502.3	—	—
114	0.068	—	9.5	1.36	—	—	0.02	12281	6.00	2500	221.4	31.5	—	—	39.1	0.2	541.6	—	—
115	0.044	0.27	9.6	3.99	104.3	—	0.13	2043	—	—	58.1	6.4	—	3.88	5.3	0.2	64.1	1.0	—
116	0.047	0.29	10.3	4.30	112.3	—	0.14	2200	—	—	62.5	6.9	—	4.18	5.7	0.2	69.0	1.1	—
117	0.210	0.33	19.1	2.99	—	—	—	1703	1.55	—	37.0	2.4	—	—	2.3	0.4	236.5	—	—
118	0.228	0.36	20.8	3.25	—	—	—	1852	1.68	—	40.2	2.6	—	—	2.5	0.4	257.2	—	—
119	0.050	1.13	13.3	4.89	95.3	—	0.10	2010	—	—	49.0	4.2	—	8.73	4.5	0.6	109.0	0.9	—
120	0.054	1.22	14.3	5.26	102.5	—	0.11	2162	—	—	52.8	4.5	—	9.39	4.9	0.7	117.3	1.0	—
121	0.017	—	0.5	0.72	—	58.7	0.38	—	—	3648	8.4	22.8	—	4.73	19.7	3.8	—	—	—
122	0.018	—	0.5	0.76	—	61.2	0.40	—	—	3800	8.8	23.8	—	4.95	20.6	3.9	—	—	—
123	0.005	0.12	2.1	1.02	40.8	67.9	0.33	1387	0.62	—	11.4	36.8	—	4.23	19.1	3.8	33.4	9.4	—
124	0.005	0.13	2.3	1.09	43.6	72.2	0.35	1480	0.66	—	12.2	39.3	—	4.52	20.4	4.0	35.6	10.0	—
125	—	—	—	0.20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
126	—	—	—	0.22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
127	0.007	0.19	4.5	0.02	—	—	—	831	—	—	41.4	4.5	3.6	—	2.3	—	—	—	—
128	0.009	0.24	5.7	0.03	—	—	—	1063	—	—	52.9	5.7	3.7	—	2.9	—	—	—	—
129	0.021	0.39	46.8	0.26	—	—	—	773	—	—	35.4	37.6	—	—	3.3	0.9	—	5.1	—
130	0.024	0.43	51.9	0.29	—	—	—	857	—	—	39.2	41.6	—	—	3.7	1.0	—	5.6	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
131	—sugarcane, molasses, mt	4-04-696	75	1972	2867	3.9	0.1	—	63.8	7.7	0.78	60.0	1.567
132	48% invert sugar mt 79.5 degrees brix		*100*	*2647*	*3823*	*5.2*	*0.1*	—	*85.7*	*10.3*	*1.05*	*80.5*	*2.103*
133	MONO-DICALCIUM	6-26-137	98	—	—	—	—	—	—	83.2	16.0	70.0	—
134	PHOSPHATE.		*100*	—	—	—	—	—	—	*84.9*	*16.3*	*71.4*	—
	OATS. *Avena sativa*												
135	—cereal by-product, lt 4%	4-03-303	91	3144	4220	14.6	6.5	4.4	62.8	2.3	0.07	4.4	—
136	fiber (Feeding oat meal)		*100*	*3471*	*4637*	*16.2*	*7.2*	*4.8*	*69.4*	*2.5*	*0.08*	*4.8*	—
137	—grain	4-03-309	89	2537	3687	12.1	4.9	10.8	57.7	3.0	0.06	5.8	0.088
138			*100*	*2865*	*4143*	*13.6*	*5.6*	*12.2*	*65.2*	*3.3*	*0.07*	*6.5*	*0.099*
139	—groats	4-03-331	89	3174	4112	15.6	6.3	2.6	62.5	2.3	0.08	5.9	—
140			*100*	*3552*	*4620*	*17.5*	*7.0*	*2.9*	*69.9*	*2.6*	*0.09*	*6.6*	—
141	—hulls	1-03-281	93	380	3906	3.6	1.6	31.0	50.6	5.8	0.13	4.1	—
142			*100*	*410*	*4200*	*3.9*	*1.8*	*33.5*	*54.6*	*6.2*	*0.14*	*4.5*	—
	OYSTERS. *Crassostrea* spp., *Ostrea* spp.												
143	—shells, grnd fine	6-03-481	99	37	—	1.0	—	—	—	87.0	37.67	—	—
144	(Oyster shell flour)		*100*	*38*	—	*1.0*	—	—	—	*88.3*	*38.22*	—	—
	PEA. *Pisum* spp.												
145	—seeds	5-03-600	89	2146	3427	22.4	1.3	8.1	54.0	3.0	0.12	—	—
146			*100*	*2418*	*3851*	*25.2*	*1.4*	*9.2*	*60.9*	*3.3*	*0.13*	—	—
	PEANUT. *Arachis hypogaea*												
147	—kernels, meal mech extd	5-03-649	90	—	4618	44.0	7.3	7.8	25.3	5.3	0.16	—	—
148	(Peanut meal)		*100*	—	*5131*	*49.0*	*8.2*	*8.7*	*28.1*	*5.9*	*0.18*	—	—
149	—kernels, meal solv extd	5-03-650	92	2705	4431	48.9	1.4	9.7	26.1	6.3	0.20	15.3	0.066
150	(Peanut meal)		*100*	*2928*	*4817*	*52.9*	*1.5*	*10.6*	*28.3*	*6.8*	*0.22*	*16.6*	*0.071*
	PHOSPHATE.												
151	—defluorinated grnd	6-01-780	100	—	—	—	—	—	—	99.2	31.59	66.0	—
152			*100*	—	—	—	—	—	—	*99.4*	*31.65*	*66.2*	—
	POTATO. *Solanum tuberosum*												
153	—tubers, dehy	4-07-850	91	2955	3562	7.9	0.5	2.0	73.7	6.9	0.06	—	—
154			*100*	*3250*	*3915*	*8.7*	*0.5*	*2.2*	*81.0*	*7.6*	*0.07*	—	—
	POULTRY.												
155	—by-products, meal	5-03-798	93	2827	4724	57.8	12.3	2.3	5.6	15.2	3.88	14.1	3.080
156	rendered		*100*	*3033*	*5080*	*62.0*	*13.2*	*2.5*	*6.0*	*16.3*	*4.17*	*15.1*	*3.305*
157	—feathers, hydrolyzed meal	5-03-795	93	2365	5227	85.4	3.0	1.2	0.0	3.5	0.28	6.5	0.043
158			*100*	*2538*	*5620*	*91.7*	*3.2*	*1.3*	*0.0*	*3.8*	*0.32*	*7.0*	*0.047*

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinosital (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
131	0.019	0.35	42.6	0.09	22.4	—	0.70	739	—	—	40.4	38.9	—	6.46	2.8	0.9	—	5.0	—
132	*0.026*	*0.47*	*57.1*	*0.11*	*30.0*	—	*0.94*	*992*	—	—	*54.2*	*52.2*	—	*8.67*	*3.8*	*1.2*	—	*6.7*	—
133	0.700	0.50	2.20	21.0	210.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
134	*0.714*	*0.51*	*2.24*	*21.4*	*214.0*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
135	0.030	0.16	43.3	0.44	139.3	—	0.22	1143	—	—	20.8	17.9	—	—	1.8	7.0	—	23.9	—
136	*0.033*	*0.18*	*47.8*	*0.48*	*153.8*	—	*0.24*	*1262*	—	—	*23.0*	*19.7*	—	—	*1.9*	*7.7*	—	*26.4*	—
137	0.008	0.12	36.8	0.32	36.4	—	0.24	1008	—	—	13.6	7.1	—	2.49	1.5	6.4	—	12.9	—
138	*0.009*	*0.14*	*41.6*	*0.37*	*41.1*	—	*0.27*	*1138*	—	—	*15.3*	*8.0*	—	*2.81*	*1.7*	*7.2*	—	*14.5*	—
139	0.008	0.10	46.2	0.42	—	—	—	1160	—	—	16.1	13.2	—	3.16	15.0	11.6	—	14.7	—
140	*0.009*	*0.11*	*51.7*	*0.47*	—	—	—	*1298*	—	—	*18.0*	*14.8*	—	*3.54*	*16.8*	*13.0*	—	*16.5*	—
141	0.010	0.08	18.9	0.13	—	—	—	286	0.96	—	9.2	3.1	0.1	2.19	1.7	0.6	—	—	—
142	*0.011*	*0.09*	*20.4*	*0.14*	—	—	—	*308*	*1.04*	—	*10.0*	*3.4*	*0.1*	*2.37*	*1.9*	*0.7*	—	—	—
143	0.283	0.30	132.2	0.07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
144	*0.287*	*0.30*	*134.1*	*0.07*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
145	0.005	—	—	0.42	29.3	—	—	632	—	—	33.1	9.8	1.2	0.98	2.3	101.5	—	—	—
146	*0.006*	—	—	*0.47*	*33.0*	—	—	*712*	—	—	*37.3*	*11.0*	*1.4*	*1.10*	*2.6*	*114.4*	—	—	—
147	—	0.32	25.3	0.56	—	—	—	1646	—	1800	165.2	47.1	—	—	5.2	7.1	—	—	—
148	—	*0.36*	*28.2*	*0.62*	—	—	—	*1833*	—	*2000*	*184.0*	*52.5*	—	—	*5.8*	*7.9*	—	—	—
149	0.027	0.26	27.0	0.64	32.9	—	0.33	1971	—	—	172.6	50.4	—	5.48	11.0	5.7	—	—	—
150	*0.029*	*0.28*	*29.2*	*0.69*	*35.6*	—	*0.36*	*2133*	—	—	*186.8*	*54.5*	—	*5.93*	*11.9*	*6.2*	—	—	—
151	0.707	0.27	695.0	13.67	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—
152	*0.709*	*0.27*	*696.4*	*13.70*	—	—	—	—	—	—	—	—	*0.1*	—	—	—	—	—	—
153	—	—	2.3	0.19	2.0	—	0.10	2618	—	—	33.2	20.0	—	14.10	0.7	—	—	—	—
154	—	—	*2.5*	*0.21*	*2.2*	—	*0.11*	*2879*	—	—	*36.5*	*22.0*	—	*15.50*	*0.7*	—	—	—	—
155	0.076	0.21	20.0	2.09	569.8	—	0.19	6036	—	—	52.9	11.9	—	4.40	10.3	0.2	300.4	2.1	—
156	*0.082*	*0.22*	*21.5*	*2.25*	*611.3*	—	*0.20*	*6475*	—	—	*56.8*	*12.8*	—	*4.72*	*11.0*	*0.2*	*322.2*	*2.3*	—
157	0.008	0.21	8.7	0.67	54.3	—	0.25	898	—	—	21.9	9.5	—	4.43	2.1	0.1	80.9	—	—
158	*0.008*	*0.22*	*9.3*	*0.71*	*58.3*	—	*0.27*	*964*	—	—	*23.5*	*10.2*	—	*4.75*	*2.2*	*0.1*	*86.8*	—	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
	RICE. *Oryza sativa*												
159	—bran w germ (Rice bran)	4-03-928	91	1992	4232	12.7	13.9	11.6	40.5	12.2	0.08	13.0	—
160			*100*	*2192*	*4651*	*14.0*	*15.2*	*12.7*	*44.6*	*13.5*	*0.09*	*14.3*	—
161	—grain, grnd (Ground	4-03-938	89	2668	3316	9.6	1.7	9.1	63.9	4.7	0.06	6.3	0.044
162	rough rice)		*100*	*2995*	*3726*	*10.8*	*1.9*	*10.3*	*71.7*	*5.3*	*0.07*	*7.1*	*0.050*
163	—groats, polished (Rice,	4-03-942	89	3084	3641	7.2	0.4	0.4	80.0	0.5	0.02	2.9	—
164	polished)		*100*	*3483*	*4091*	*8.2*	*0.5*	*0.4*	*90.3*	*0.6*	*0.02*	*3.3*	—
165	—polishings	4-03-943	90	3133	2644	12.1	12.6	3.2	54.7	7.6	0.05	7.2	0.066
166			*100*	*3474*	*2938*	*13.4*	*13.9*	*3.6*	*60.6*	*8.4*	*0.05*	*7.9*	*0.073*
	RYE. *Secale cereale*												
167	—grain	4-04-047	87	2529	3327	12.1	1.5	2.2	69.9	1.6	0.06	6.7	—
168			*100*	*2896*	*3824*	*13.8*	*1.7*	*2.5*	*80.1*	*1.9*	*0.07*	*7.7*	—
	SEAWEED. Laminariales (order), Fucales (order)												
169	—whole, s-c	1-04-190	89	—	3381	8.8	2.2	5.5	59.8	12.8	1.63	—	—
170			*100*	—	*3799*	*9.8*	*2.5*	*6.2*	*67.1*	*14.4*	*1.83*	—	—
	SESAME. *Sesamum indicum*												
171	—seeds, meal mech extd	5-04-220	93	2327	4516	44.3	7.9	5.7	23.7	11.2	2.01	—	—
172			*100*	*2511*	*4855*	*47.7*	*8.5*	*6.1*	*25.5*	*12.1*	*2.17*	—	—
	SHRIMP. *Pandalus* spp., *Penaeus* spp.												
173	—cannery residue, meal	5-04-226	90	2157	2951	44.8	3.0	11.3	3.7	27.1	7.23	—	—
174	(Shrimp meal)		*100*	*2401*	*4216*	*49.9*	*3.3*	*12.5*	*4.1*	*30.2*	*8.05*	—	—
175	SODIUM TRIPOLY-	6-08-076	100	—	—	—	—	—	—	93.0	—	—	—
176	PHOSPHATE. $Na_5P_3O_{10}$		*100*	—	—	—	—	—	—	*93.0*	—	—	—
	SORGHUM. *Sorghum vulgare*												
177	—grain	4-04-383	90	3328	3838	11.3	2.8	2.4	71.5	1.7	0.03	9.7	0.022
178			*100*	*3705*	*4264*	*12.6*	*3.1*	*2.7*	*79.6*	*1.9*	*0.03*	*10.8*	*0.025*
	SOYBEAN. *Glycine max*												
179	—seeds, meal mech extd	5-04-600	90	2438	4355	42.4	4.6	6.1	31.0	6.1	0.27	21.8	—
180			*100*	*2703*	*4839*	*47.0*	*5.1*	*6.8*	*34.4*	*6.8*	*0.30*	*24.1*	—
181	—seeds, meal solv extd	5-04-604	89	2389	4204	45.4	1.2	5.8	30.9	6.0	0.28	27.4	0.131
182			*100*	*2676*	*4723*	*50.9*	*1.3*	*6.5*	*34.6*	*6.7*	*0.31*	*30.7*	*0.147*
183	—seeds wo hulls, meal solv	5-04-612	90	2463	4185	48.8	1.0	3.6	31.1	5.9	0.25	14.9	0.109
184	extd		*100*	*2725*	*4650*	*54.0*	*1.1*	*4.0*	*34.4*	*6.5*	*0.27*	*16.4*	*0.120*
	SUGARCANE. *Saccharum officinarum* —molasses—see Molasses												

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
159	0.019	0.95	346.3	1.48	30.0	—	0.42	1222	—	—	299.8	23.1	—	29.20	2.6	22.5	—	59.9	—
160	0.021	1.05	381.0	1.62	33.0	—	0.46	1344	—	—	329.8	25.4	—	32.12	2.9	24.8	—	65.9	—
161	0.010	0.23	96.3	0.43	13.3	—	0.08	926	0.29	—	35.4	7.0	—	4.42	1.0	2.9	—	9.9	—
162	0.011	0.25	108.1	0.48	14.9	—	0.09	1039	0.33	—	39.7	7.8	—	4.97	1.2	3.2	—	11.2	—
163	0.001	0.02	10.9	0.11	2.0	—	—	899	—	—	15.5	3.5	—	0.39	0.5	0.7	—	3.5	—
164	0.002	0.02	12.4	0.12	2.2	—	—	1016	—	—	17.5	4.0	—	0.45	0.6	0.7	—	4.0	—
165	0.012	0.65	171.2	1.32	26.4	—	0.62	1227	—	—	541.5	38.0	—	27.79	1.8	20.1	—	72.1	—
166	0.013	0.72	189.8	1.47	29.3	—	0.68	1360	—	—	600.4	42.1	—	30.81	2.0	22.2	—	79.9	—
167	0.006	0.12	54.6	0.32	31.5	—	0.32	—	0.64	—	20.4	8.9	—	2.56	1.6	3.0	—	15.0	—
168	0.007	0.14	62.5	0.36	36.1	—	0.37	—	0.73	—	23.3	10.2	—	2.94	1.8	3.4	—	17.2	—
169	—	5.68	—	0.16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
170	—	6.37	—	0.18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
171	—	0.79	47.8	1.38	99.7	—	—	1542	—	—	21.6	6.0	—	12.46	3.4	2.8	—	—	—
172	—	0.86	51.5	1.49	107.5	—	—	1664	—	—	23.3	6.4	—	13.44	3.7	3.0	—	—	—
173	0.011	0.54	30.1	1.54	—	—	—	5356	—	—	—	—	5.0	—	4.0	—	—	—	—
174	0.012	0.60	33.5	1.71	—	—	—	5961	—	—	—	—	5.8	—	4.4	—	—	—	—
175	0.004	—	—	25.07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
176	0.004	—	—	25.07	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
177	0.005	0.18	15.5	0.30	14.5	—	0.25	628	—	—	41.2	11.7	0.2	4.67	1.3	4.2	—	10.9	—
178	0.005	0.20	17.3	0.33	16.1	—	0.28	699	—	—	45.8	13.0	0.2	5.19	1.4	4.7	—	12.1	—
179	0.016	0.26	31.4	0.60	59.8	—	0.33	2659	6.62	—	31.7	14.3	0.3	—	3.5	3.4	—	6.6	—
180	0.017	0.28	34.8	0.66	66.3	—	0.36	2948	7.35	—	35.1	15.8	0.3	—	3.9	3.7	—	7.3	—
181	0.012	0.27	28.5	0.63	42.7	—	0.32	2637	0.59	—	27.6	16.2	0.3	6.41	2.9	5.5	2.0	2.0	—
182	0.013	0.30	31.9	0.70	47.9	—	0.36	2955	0.67	—	30.9	18.1	0.3	7.18	3.3	6.2	2.2	2.3	—
183	0.011	—	38.6	0.62	49.9	—	0.32	2513	—	—	21.6	15.0	0.5	4.78	2.9	2.9	2.0	1.7	—
184	0.012	—	42.7	0.68	55.2	—	0.36	2780	—	—	23.9	16.6	0.6	5.29	3.3	3.2	2.2	1.9	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free) ME$_n$ Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
	SUNFLOWER. *Helianthus* spp.												
185	—seeds wo hulls, meal mech	5-04-738	93	2214	4740	41.7	8.4	11.6	24.5	6.5	0.38	3.5	—
186	extd		100	2391	5097	45.1	9.0	12.5	26.4	7.0	0.42	3.8	—
187	—seeds wo hulls, meal solv	5-04-739	93	2054	4467	46.3	2.7	11.0	25.5	7.4	0.38	3.5	—
188	extd		100	2210	4803	49.8	3.0	11.8	27.4	8.0	0.41	3.8	—
	TOMATO. *Lycopersicon esculentum*												
189	—pomace, dehy	5-05-041	92	1750	4056	21.6	9.4	24.1	29.7	6.9	0.39	29.9	—
190			100	1908	4409	23.5	10.3	26.3	32.4	7.5	0.42	32.6	—
	WHALE. *Balaena glacialis, Balaenoptera* spp., *Physeter catadon*												
191	—meat, meal rendered	5-05-160	92	—	5184	71.5	7.6	0.3	8.0	4.0	0.40	—	—
192			100	—	5634	78.1	8.4	0.3	8.8	4.4	0.44	—	—
	WHEAT. *Triticum* spp.												
193	—bran	4-05-190	89	1231	4064	15.1	3.9	10.3	53.1	6.2	0.11	12.6	0.065
194			100	1388	4567	17.0	4.4	11.7	59.9	7.0	0.12	14.3	0.073
195	—flour, lt 2% fiber	4-05-199	87	2882	3820	11.6	1.2	1.1	72.8	0.5	0.03	1.6	—
196			100	3307	4391	13.3	1.3	1.2	83.6	0.5	0.03	1.8	—
197	—germ, meal	5-05-218	88	2783	4392	24.5	8.4	3.1	48.0	4.1	0.05	9.3	—
198			100	3158	4991	27.8	9.5	3.5	54.5	4.7	0.06	10.6	—
199	—grain	4-05-211	88	2950	3838	14.9	1.8	2.5	67.4	1.6	0.03	5.7	0.087
200			100	3343	4361	16.9	2.0	2.8	76.4	1.8	0.04	6.5	0.098
201	—grain, hard red spring	4-05-258	88	2731	3929	15.4	1.8	2.5	66.4	1.6	0.03	5.7	—
202			100	3118	4465	17.6	2.0	2.8	75.8	1.8	0.04	6.5	—
203	—grain, hard red winter	4-05-268	88	3214	3803	12.6	1.6	2.5	69.7	1.7	0.04	4.7	—
204			100	3648	4321	14.4	1.8	2.8	79.1	1.9	0.05	5.4	—
205	—grain screenings	4-05-216	89	2671	3829	14.2	3.4	7.5	58.1	6.0	0.15	—	—
206			100	2992	4303	16.0	3.8	8.4	65.1	6.7	0.17	—	—
207	—grain, soft red winter	4-05-294	88	—	3749	11.5	1.6	2.2	71.1	1.8	0.04	6.1	—
208			100	—	4260	13.0	1.8	2.4	80.6	2.1	0.05	6.9	—
209	—grain, soft white winter	4-05-337	88	3114	3684	9.9	1.8	2.3	72.6	1.7	0.06	7.4	—
210			100	3528	4186	11.2	2.0	2.6	82.3	1.9	0.07	8.4	—
211	—grits	4-07-852	90	—	3722	11.4	0.9	0.4	76.6	0.4	0.03	—	—
212			100	—	4136	12.7	1.0	0.4	85.4	0.4	0.03	—	—
213	—middlings, lt 9.5% fiber	4-05-205	89	2101	4139	16.7	4.6	7.0	56.5	4.5	0.11	18.4	0.109

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinositol (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B_{12} (μg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
185	0.003	0.73	20.7	1.06	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—
186	0.004	0.79	22.4	1.14	—	—	—	—	—	—	—	—	0.1	—	—	—	—	—	—
187	0.003	0.73	14.4	1.05	—	—	—	3613	—	—	257.6	30.2	0.1	15.99	3.9	—	—	11.2	—
188	0.004	0.78	15.5	1.13	—	—	—	3887	—	—	277.1	32.5	0.1	17.20	4.2	—	—	12.0	—
189	0.422	0.18	46.8	0.55	—	—	—	—	—	—	—	—	—	—	6.1	11.7	—	—	—
190	0.460	0.20	51.0	0.60	—	—	—	—	—	—	—	—	—	—	6.7	12.7	—	—	—
191	—	—	—	0.56	—	—	—	—	—	—	104.3	2.6	—	8.32	8.3	1.3	88.0	—	—
192	—	—	—	0.61	—	—	—	—	—	—	113.9	2.9	—	9.10	9.1	1.4	96.2	—	—
193	0.010	0.52	109.5	1.27	103.5	—	0.57	1874	1.66	—	273.3	31.6	—	10.15	4.8	6.5	—	20.8	—
194	0.012	0.59	123.4	1.43	116.7	—	0.64	2113	1.86	—	308.2	35.7	—	11.44	5.4	7.3	—	23.4	—
195	0.003	0.02	9.8	0.19	6.3	—	—	800	—	830	13.4	5.3	—	0.85	0.4	1.7	—	2.4	—
196	0.003	0.03	11.2	0.22	7.2	—	—	918	—	865	15.3	6.1	—	0.98	0.5	1.9	—	2.8	—
197	0.005	0.24	133.4	0.92	119.6	—	0.22	3061	2.02	6900	72.4	20.9	—	11.34	6.1	22.7	—	141.2	—
198	0.006	0.28	151.4	1.04	135.7	—	0.24	3473	2.30	7840	82.2	23.7	—	12.87	6.9	25.8	—	160.3	—
199	0.006	0.15	36.8	0.38	44.8	—	0.10	1008	0.43	1700	57.1	9.7	—	5.01	1.4	4.2	0.9	13.8	—
200	0.006	0.17	41.7	0.43	50.8	—	0.11	1142	0.49	1932	64.7	11.0	—	5.68	1.6	4.8	1.0	15.6	—
201	0.006	0.15	36.6	0.38	45.3	—	0.11	1051	0.43	—	57.0	9.6	1.2	5.05	1.4	4.2	—	12.6	—
202	0.007	0.17	41.7	0.43	51.8	—	0.13	1200	0.49	—	65.1	10.9	1.4	5.77	1.6	4.8	—	14.4	—
203	0.003	0.10	29.0	0.38	37.7	—	0.11	1036	0.35	—	53.7	9.9	—	3.00	1.5	4.2	—	11.0	—
204	0.004	0.12	32.9	0.43	42.8	—	0.12	1175	0.40	—	60.9	11.2	—	3.40	1.7	4.8	—	12.5	—
205	—	—	14.5	0.36	—	—	—	—	—	—	—	—	—	—	—	6.4	—	—	—
206	—	—	16.2	0.40	—	—	—	—	—	—	—	—	—	—	—	7.2	—	—	—
207	0.003	0.10	31.8	0.38	42.1	—	—	929	0.40	—	52.1	9.6	5.1	3.20	1.5	4.5	—	15.6	—
208	0.003	0.11	36.0	0.43	47.7	—	—	1053	0.46	—	59.1	10.9	5.8	3.63	1.7	5.1	—	17.7	—
209	0.004	0.10	40.2	0.31	22.6	—	0.11	953	—	—	52.8	10.9	5.1	4.08	1.2	4.7	—	13.6	—
210	0.005	0.11	45.5	0.36	25.6	—	0.12	1079	—	—	59.8	12.4	5.8	4.62	1.3	5.3	—	15.4	—
211	0.002	—	—	0.11	—	—	—	—	—	—	7.0	—	—	—	1.0	0.6	—	—	—
212	0.002	—	—	0.12	—	—	—	—	—	—	7.8	—	—	—	1.1	0.7	—	—	—
213	0.008	0.36	112.6	0.83	151.4	—	0.11	1257	0.98	—	96.0	18.1	—	5.68	2.0	14.9	—	21.4	—

TABLE 10 Composition of Some Common Fish Feeds, Excluding Amino Acids—Continued

				As-Fed and Dry Basis (Moisture Free)									
Line Number	SCIENTIFIC NAME Short Name	International Feed Number[a]	Dry Matter (%)	ME_n Chickens (kcal/kg)	Gross Energy (kcal/kg)	Protein (%)	Ether Extract (%)	Crude Fiber (%)	Nitrogen-Free Extract (%)	Ash (%)	Calcium (%)	Copper (mg/kg)	Iodine (mg/kg)
214			100	2353	4650	18.7	5.2	7.8	63.2	5.0	0.12	20.6	0.12
215	—mill run, lt 9.5% fiber	4-05-206	90	1746	3964	15.7	4.1	8.3	56.9	5.2	0.15	18.8	—
216			100	1935	4404	17.4	4.6	9.2	63.1	5.8	0.17	20.8	—
217	—red dog, lt 4.5% fiber	4-05-203	88	2592	4062	15.3	3.3	2.4	64.5	2.2	0.04	6.4	—
218			100	2955	4616	17.4	3.8	2.7	73.6	2.5	0.05	7.3	—
219	—shorts, lt 8% fiber	4-05-201	88	2182	4358	16.4	4.9	6.5	56.4	3.9	0.09	11.7	—
220			100	2477	4952	18.6	5.5	7.4	64.0	4.5	0.10	13.3	—
	WHEAT, DURUM. *Triticum durum*												
221	—grain	4-05-224	87	—	3320	13.8	1.8	2.3	67.5	1.6	0.08	6.9	—
222			100	—	3816	15.9	2.0	2.6	77.6	1.8	0.10	7.9	—
	WHEY. *Bos taurus*												
223	—dehy	4-01-182	93	1957	3393	13.1	0.6	0.2	70.0	9.4	0.78	45.9	—
224			100	2097	3649	14.0	0.7	0.2	75.0	10.1	0.84	49.2	—
225	—low lactose, dehy (Dried	4-01-186	93	1965	3153	16.5	1.1	0.2	59.2	15.8	1.74	—	—
226	whey product)		100	2115	3390	17.8	1.2	0.2	63.8	17.0	1.88	—	—
	YEAST. *Candida utilis*												
227	—petroleum, solv extd dehy	7-09-836	92	—	—	47.0	—	—	—	—	0.02	—	—
228			100	—	—	51.1	—	—	—	—	0.02	—	—
	YEAST. *Saccharomyces cerevisiae*												
229	—brewers, dehy	7-05-527	93	2108	4054	45.1	1.1	2.7	37.8	6.8	0.14	33.3	—
230			100	2255	4359	48.3	1.1	2.9	40.4	7.2	0.15	35.6	—
231	—primary, dehy	7-05-533	93	—	4455	48.0	1.0	3.1	32.5	8.0	0.36	—	—
232			100	—	4790	51.8	1.1	3.3	35.1	8.6	0.39	—	—
	YEAST. *Torulopsis utilis*												
233	—torula, dehy	7-05-534	93	2020	4483	47.8	2.4	2.4	32.3	8.0	0.58	13.4	—
234			100	2175	4821	51.5	2.6	2.5	34.8	8.6	0.63	14.4	—

[a] The first digit is the feed class: (1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

As-Fed and Dry Basis (Moisture Free)

Line Number	Iron (%)	Magnesium (%)	Manganese (mg/kg)	Phosphorus (%)	Zinc (mg/kg)	Ascorbic acid (mg/kg)	Biotin (mg/kg)	Choline (mg/kg)	Folic acid (mg/kg)	Myoinosital (mg/kg)	Niacin (mg/kg)	Pantothenic acid (mg/kg)	Vitamin A Equiv. (mg/kg)	Pyridoxine (mg/kg)	Riboflavin (mg/kg)	Thiamine (mg/kg)	Vitamin B12 (µg/kg)	Vitamin E (mg/kg)	Vitamin K (mg/kg)
214	*0.009*	*0.40*	*126.1*	*0.93*	*169.6*	—	*0.12*	*1408*	*1.10*	—	*107.5*	*20.3*	—	*6.36*	*2.2*	*16.6*	—	*23.9*	—
215	0.010	0.51	102.6	1.03	—	—	—	992	—	—	111.2	13.3	—	—	1.6	15.3	—	—	—
216	*0.011*	*0.57*	*113.8*	*1.14*	—	—	—	*1099*	—	—	*123.2*	*14.7*	—	—	*1.8*	*16.9*	—	—	—
217	0.004	0.14	55.3	0.48	64.8	—	0.11	1598	0.76	—	45.8	13.4	—	4.82	2.4	22.9	—	32.7	—
218	*0.005*	*0.16*	*63.0*	*0.55*	73.9	—	0.12	1821	0.86	—	52.2	15.2	—	5.49	2.7	26.1	—	37.3	—
219	0.007	0.26	117.0	0.81	106.4	—	—	2029	1.60	—	108.0	23.3	—	7.18	4.6	19.8	—	54.1	—
220	*0.008*	*0.29*	*132.8*	*0.92*	*120.8*	—	—	*2303*	*1.82*	—	*122.5*	*26.4*	—	*8.15*	*5.2*	*22.4*	—	*61.4*	—
221	0.004	0.14	27.9	0.35	32.6	—	—	—	0.38	—	51.9	8.8	1.5	2.98	1.0	4.6	—	—	—
222	*0.005*	*0.16*	*32.0*	*0.41*	*37.4*	—	—	—	*0.44*	—	*59.6*	*10.1*	*1.7*	*3.42*	*1.2*	*5.3*	—	—	—
223	0.015	0.13	5.5	0.77	3.2	—	0.35	1776	0.87	—	10.6	46.1	0.5	3.35	26.3	4.0	18.0	—	—
224	*0.016*	*0.14*	*5.9*	*0.83*	*3.4*	—	*0.38*	*1904*	*0.94*	—	*11.4*	*49.4*	*0.5*	*3.59*	*28.2*	*4.3*	*19.2*	—	—
225	—	—	—	1.33	—	—	0.48	4282	—	—	17.9	75.2	—	5.34	45.7	5.2	41.7	—	—
226	—	—	—	*1.43*	—	—	*0.52*	*4609*	—	—	*19.3*	*80.9*	—	*5.74*	*49.2*	*5.6*	*44.8*	—	—
227	—	—	—	5.40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
228	—	—	—	*5.87*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
229	0.011	0.23	5.8	1.42	39.3	—	0.97	4096	9.66	500	460.1	109.6	—	43.47	36.6	93.5	—	2.2	—
230	*0.012*	*0.25*	*6.2*	*1.52*	*42.0*	—	*1.04*	*4381*	*10.39*	*538*	*492.2*	*117.2*	—	*46.50*	*39.2*	*100.0*	—	*2.4*	—
231	0.030	0.36	3.7	1.72	—	—	1.61	—	31.27	—	300.7	312.0	1.4	—	38.8	6.4	6.2	—	—
232	*0.032*	*0.39*	*4.0*	*1.86*	—	—	*1.74*	—	*33.62*	—	*324.7*	*336.9*	*1.5*	—	*41.9*	*6.9*	*6.7*	—	—
233	0.009	0.13	12.8	1.67	99.0	—	1.39	2883	23.25	—	497.8	83.0	—	29.40	49.2	6.2	—	—	—
234	*0.010*	*0.14*	*13.8*	*1.80*	*106.6*	—	*1.50*	*3104*	*25.00*	—	*536.1*	*89.3*	—	*31.66*	*52.9*	*6.7*	—	—	—

TABLE 11 Amino Acid Composition of Some Common Fish Feeds

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free) Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	ALFALFA. *Medicago sativa*														
001	—meal dehy, 15% protein	1-00-022	91	0.59	0.24	0.26	0.64	1.03	0.60	0.22	0.62	0.55	0.39	0.41	0.72
002			*100*	*0.65*	*0.26*	*0.28*	*0.70*	*1.13*	*0.66*	*0.24*	*0.68*	*0.60*	*0.43*	*0.45*	*0.79*
003	—meal dehy, 17% protein	1-00-023	92	0.75	0.29	0.33	0.81	1.28	0.88	0.21	0.79	0.70	0.36	0.55	0.85
004			*100*	*0.81*	*0.32*	*0.36*	*0.87*	*1.39*	*0.96*	*0.23*	*0.86*	*0.76*	*0.39*	*0.60*	*0.92*
005	—meal dehy, 20% protein	1-00-024	91	0.94	0.31	0.36	0.87	1.38	0.90	0.31	0.92	0.80	0.43	0.62	1.00
006			*100*	*1.03*	*0.34*	*0.40*	*0.95*	*1.51*	*0.99*	*0.34*	*1.01*	*0.87*	*0.47*	*0.68*	*1.09*
007	—meal dehy, 22% protein	1-07-851	93	0.99	0.34	0.44	1.07	1.60	1.00	0.34	1.13	0.98	0.48	0.65	1.29
008			*100*	*1.06*	*0.36*	*0.48*	*1.16*	*1.73*	*1.08*	*0.37*	*1.22*	*1.05*	*0.52*	*0.70*	*1.39*
	BARLEY. *Hordeum vulgare*														
009	—grain	4-00-549	88	0.53	0.23	0.25	0.47	0.80	0.42	0.15	0.60	0.38	0.15	0.32	0.60
010			*100*	*0.60*	*0.26*	*0.29*	*0.54*	*0.91*	*0.48*	*0.18*	*0.69*	*0.43*	*0.18*	*0.36*	*0.68*
011	—grain, Pacific Coast	4-07-939	90	0.44	0.20	0.20	0.41	0.60	0.25	0.14	0.47	0.30	0.13	0.31	0.47
012			*100*	*0.50*	*0.23*	*0.23*	*0.45*	*0.67*	*0.28*	*0.16*	*0.53*	*0.34*	*0.14*	*0.34*	*0.52*
013	—malt sprouts, dehy	5-00-545	92	1.11	0.23	0.53	1.09	1.63	1.22	0.33	0.91	1.01	0.41	—	1.45
014			*100*	*1.21*	*0.25*	*0.57*	*1.18*	*1.77*	*1.32*	*0.36*	*0.98*	*1.09*	*0.44*	—	*1.58*
	BEET, SUGAR. *Beta vulgaris, saccharifera*														
	—molasses—see Molasses, beet														
015	—pulp, dehy	4-00-669	90	0.30	0.01	0.20	0.30	0.60	0.60	0.01	0.30	0.40	0.10	0.40	0.40
016			*100*	*0.33*	*0.01*	*0.22*	*0.33*	*0.66*	*0.66*	*0.01*	*0.33*	*0.44*	*0.11*	*0.44*	*0.44*
	BLOOD. Animal														
017	—meal	5-00-380	92	3.19	1.31	3.96	0.90	10.12	5.99	0.91	5.47	3.47	1.02	1.73	6.41
018			*100*	*3.47*	*1.43*	*4.31*	*0.98*	*11.02*	*6.53*	*0.99*	*5.96*	*3.78*	*1.11*	*1.89*	*6.99*
019	—meal spray dehy	5-00-381	86	3.15	—	4.55	1.02	9.83	7.70	1.02	5.29	3.43	0.93	1.86	6.87
020			*100*	*3.69*	—	*5.31*	*1.19*	*11.50*	*9.00*	*1.19*	*6.18*	*4.01*	*1.08*	*2.17*	*8.03*
	BONE. Animal														
021	—meal steamed	6-00-400	97	—	—	—	—	—	—	—	—	—	—	—	—
022			*100*	—	—	—	—	—	—	—	—	—	—	—	—
023	—phosphate	6-00-406	97	—	—	—	—	—	—	—	—	—	—	—	—
024			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	BREWERS.														
025	—grains, dehy	5-02-141	92	1.22	0.38	0.49	1.47	1.89	0.87	0.45	1.38	0.88	0.37	1.20	1.59
026			*100*	*1.33*	*0.41*	*0.54*	*1.60*	*2.05*	*0.95*	*0.49*	*1.50*	*0.95*	*0.40*	*1.30*	*1.73*
	BUTTERMILK. *Bos taurus*														
027	—condensed	5-01-159	29	—	—	—	—	—	—	—	—	—	—	—	—
028			*100*	—	—	—	—	—	—	—	—	—	—	—	—
029	—dehy	5-01-160	92	1.08	0.39	0.85	2.37	3.20	2.28	0.71	1.47	1.52	0.49	1.01	2.56
030			*100*	*1.18*	*0.42*	*0.92*	*2.58*	*3.48*	*2.47*	*0.77*	*1.60*	*1.65*	*0.53*	*1.09*	*2.78*

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
				As-Fed and Dry Basis (Moisture Free)											
031	CALCIUM CARBONATE.	6-01-071	—	—	—	—	—	—	—	—	—	—	—	—	—
032	Precipitated, $CaCO_3$		*100*	—	—	—	—	—	—	—	—	—	—	—	—
033	—dehy	5-01-162	90	3.36	0.28	2.56	5.56	8.67	7.02	2.76	4.66	3.86	0.98	4.56	6.62
034			*100*	*3.71*	*0.31*	*2.83*	*6.15*	*9.59*	*7.76*	*3.05*	*5.16*	*4.27*	*1.08*	*5.04*	*7.32*
	CITRUS. *Citrus* spp.														
035	—pulp wo fines, dehy (Dried	4-01-237	90	0.23	0.11	—	—	—	0.20	0.09	—	—	0.06	—	—
036	citrus pulp)		*100*	*0.25*	*0.12*	—	—	—	*0.22*	*0.10*	—	—	*0.07*	—	—
	COCONUT. *Cocos nucifera*														
037	—meats, meal mech extd	5-01-572	93	2.30	0.20	—	—	—	0.54	0.33	—	—	0.20	—	—
038	(Copra meal)		*100*	*2.48*	*0.22*	—	—	—	*0.58*	*0.36*	—	—	*0.22*	—	—
039	—meats, meal mech extd	5-01-573	92	2.56	0.28	0.45	0.80	1.47	0.63	0.32	0.89	0.69	0.20	0.56	1.05
040	(Copra meal)		*100*	*2.80*	*0.30*	*0.49*	*0.88*	*1.60*	*0.68*	*0.34*	*0.97*	*0.75*	*0.22*	*0.62*	*1.14*
	CORN. *Zea mays*														
041	—distillers grains w solubles,	5-02-843	92	0.93	0.27	0.65	1.39	2.21	0.73	0.50	1.51	0.94	0.15	0.70	1.50
042	dehy		*100*	*1.02*	*0.29*	*0.71*	*1.51*	*2.40*	*0.79*	*0.55*	*1.64*	*1.02*	*0.17*	*0.76*	*1.63*
043	—distillers solubles, dehy	5-02-844	92	0.98	0.47	0.67	1.31	2.23	0.88	0.58	1.47	1.00	0.20	0.86	1.53
044			*100*	*1.06*	*0.50*	*0.72*	*1.42*	*2.42*	*0.96*	*0.63*	*1.59*	*1.08*	*0.22*	*0.93*	*1.66*
045	—germ, meal wet milled solv	5-02-898	90	1.30	—	—	—	—	—	—	—	—	0.20	—	—
046	extd		*100*	*1.44*	—	—	—	—	—	—	—	—	*0.22*	—	—
047	—gluten, meal	5-02-900	91	1.42	0.65	0.97	2.24	7.43	0.83	1.07	2.82	1.43	0.21	1.01	2.24
048			*100*	*1.56*	*0.72*	*1.07*	*2.45*	*8.13*	*0.91*	*1.17*	*3.09*	*1.57*	*0.23*	*1.10*	*2.46*
049	—hominy feed	4-02-887	90	0.45	0.18	0.20	0.40	0.84	0.40	0.14	0.35	0.40	0.10	0.50	0.50
050			*100*	*0.50*	*0.20*	*0.22*	*0.44*	*0.94*	*0.44*	*0.16*	*0.39*	*0.44*	*0.11*	*0.55*	*0.55*
	CORN, DENT YELLOW. *Zea mays, indentata*														
051	—grain	4-02-935	88	0.41	0.24	0.26	0.36	1.26	0.26	0.15	0.49	0.35	0.09	0.38	0.44
052			*100*	*0.46*	*0.27*	*0.30*	*0.41*	*1.44*	*0.30*	*0.17*	*0.56*	*0.40*	*0.10*	*0.44*	*0.50*
	CORN, FLINT. *Zea mays, indurata*														
053	—grain	4-02-948	89	—	—	—	—	—	0.27	0.18	—	—	0.09	—	—
054			*100*	—	—	—	—	—	*0.30*	*0.20*	—	—	*0.10*	—	—
	COTTON. *Gossypium* spp.														
055	—seeds, meal mech extd,	5-01-617	93	4.05	0.70	1.04	1.50	2.30	1.56	0.56	2.04	1.29	0.49	0.77	1.92
056	41% protein		*100*	*4.36*	*0.76*	*1.12*	*1.62*	*2.47*	*1.68*	*0.61*	*2.20*	*1.39*	*0.53*	*0.83*	*2.07*
057	—seeds, meal prepressed solv	5-07-872	90	4.59	0.64	1.10	1.33	—	1.71	0.52	2.22	1.32	0.47	—	1.88
058	extd, 41% protein		*100*	*5.11*	*0.71*	*1.22*	*1.48*	—	*1.90*	*0.58*	*2.47*	*1.47*	*0.52*	—	*2.09*
059	—seeds, meal solv extd,	5-01-621	91	4.26	0.82	1.11	1.56	2.46	1.69	0.60	2.15	1.39	0.55	0.83	2.56
060	41% protein		*100*	*4.66*	*0.90*	*1.22*	*1.70*	*2.69*	*1.85*	*0.66*	*2.35*	*1.52*	*0.60*	*0.91*	*2.80*
061	—seeds wo hulls, meal prepressed	5-07-874	93	4.84	1.07	1.21	1.91	2.82	1.84	0.73	2.41	1.61	0.58	0.80	2.31
062	solv extd, 50% protein		*100*	*5.20*	*1.15*	*1.30*	*2.05*	*3.03*	*1.98*	*0.79*	*2.59*	*1.73*	*0.62*	*0.86*	*2.49*

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free) Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	CRAB. *Callinecies sapidus*; *Cancer* spp. *Paralithodes camschatica*														
063	—cannery residue. meal	5-01-663	93	1.66	0.19	0.49	1.16	1.54	1.39	0.53	1.16	1.01	0.29	1.16	1.46
064	(Crab meal)		*100*	*1.79*	*0.21*	*0.52*	*1.26*	*1.67*	*1.50*	*0.57*	*1.26*	*1.09*	*0.31*	*1.25*	*1.57*
	DEFLUORINATED PHOSPHATE. see Phosphate														
065	DICALCIUM PHOSPHATE.	6-01-080	97	—	—	—	—	—	—	—	—	—	—	—	—
066	$CaHP_4O \cdot 2H_2O$		*100*	—	—	—	—	—	—	—	—	—	—	—	—
	DISTILLERS GRAINS. see Corn														
	FATS AND OILS.														
067	—fat, animal—poultry	4-00-409	100	—	—	—	—	—	—	—	—	—	—	—	—
068	FEATHERS. see Poultry		*100*	—	—	—	—	—	—	—	—	—	—	—	—
	FISH, ALEWIFE. *Pomolobus pseudoharengus*														
069	—meal mech extd	5-09-830	90	4.69	0.47	1.93	3.40	—	5.49	1.93	2.91	3.29	0.63	—	3.58
070			*100*	*5.21*	*0.52*	*2.14*	*3.78*	—	*6.10*	*2.14*	*3.23*	*3.66*	*0.70*	—	*3.98*
071	—whole, fresh	5-07-964	26	—	—	—	—	—	—	—	—	—	—	—	—
072			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	FISH, ANCHOVY. *Engraulis ringen*														
073	—meal mech extd	5-01-985	92	3.78	0.60	1.59	3.12	4.98	5.02	1.99	2.80	2.76	0.75	2.24	3.51
074			*100*	*4.10*	*0.65*	*1.73*	*3.39*	*5.40*	*5.46*	*2.16*	*3.04*	*3.00*	*0.81*	*2.44*	*3.81*
	FISH, CARP. *Cyprinus carpio*														
075	—meal mech extd	5-01-987	90	—	—	—	—	—	—	1.40	—	—	—	—	—
076			*100*	—	—	—	—	—	—	*1.56*	—	—	—	—	—
077	—whole, fresh	5-01-986	29	—	—	—	—	—	—	—	—	—	—	—	—
078			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	FISH, CATFISH. *Ictalurus* spp.														
079	—boiled	5-09-833	—	—	—	—	—	—	—	—	—	—	—	—	—
080			*100*	—	—	—	—	—	—	—	—	—	—	—	—
081	—cuttings, fresh	5-09-832	—	—	—	—	—	—	—	—	—	—	—	—	—
082			*100*	—	—	—	—	—	—	—	—	—	—	—	—
083	—meal mech extd	5-09-835	—	—	—	—	—	—	—	—	—	—	—	—	—
084			*100*	—	—	—	—	—	—	—	—	—	—	—	—
085	—whole, fresh	5-07-965	22	—	—	—	—	—	—	—	—	—	—	—	—
086			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	FISH, HERRING. *Clupea harengus*														
087	—meal mech extd	5-02-000	92	4.75	0.75	1.69	3.15	5.23	5.78	2.10	2.75	2.90	0.78	2.23	4.39

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

				As-Fed and Dry Basis (Moisture Free)											
Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
088			*100*	*5.17*	*0.82*	*1.84*	*3.43*	*5.69*	*6.30*	*2.29*	*2.99*	*3.15*	*0.85*	*2.43*	*4.78*
	FISH, MENHADEN. *Brevoortia tyrannus*														
089	—meal mech extd	5-02-009	92	3.73	0.56	1.45	2.88	4.48	4.72	1.75	2.47	2.50	0.65	1.94	3.22
090			*100*	*4.08*	*0.61*	*1.58*	*3.15*	*4.90*	*5.16*	*1.91*	*2.69*	*2.73*	*0.71*	*2.11*	*3.52*
	FISH, SALMON. *Oncorhynchus* spp., *Salmo* spp.														
091	—meal mech extd	5-02-012	93	5.20	0.70	—	—	—	7.61	1.60	—	—	0.50	—	—
092			*100*	*5.59*	*0.75*	—	—	—	*8.17*	*1.72*	—	—	*0.54*	—	—
	FISH, SARDINE. *Clupea* spp., *Sardinops* spp.														
093	—meal mech extd	5-02-015	93	2.70	0.80	1.80	3.34	—	5.91	2.01	2.00	2.60	0.50	—	4.10
094			*100*	*2.90*	*0.86*	*1.93*	*3.59*	—	*6.34*	*2.16*	*2.15*	*2.79*	*0.54*	—	*4.40*
	FISH, TUNA. *Thunnus thynnus, Thunnus albacarea*														
095	—meal mech extd	5-02-023	93	3.40	0.45	1.80	2.45	3.83	4.20	1.51	2.18	2.34	0.62	1.74	2.77
096			*100*	*3.65*	*0.49*	*1.93*	*2.64*	*4.11*	*4.51*	*1.62*	*2.35*	*2.52*	*0.67*	*1.87*	*2.98*
	FISH, WHITE. Gadidae (family), Lophiidai (family), Rajidae (family)														
097	—meal mech extd	5-02-025	91	3.99	0.82	1.36	2.97	4.45	4.55	1.68	2.35	2.60	0.69	1.98	3.09
098			*100*	*4.38*	*0.90*	*1.49*	*3.25*	*4.88*	*4.99*	*1.85*	*2.59*	*2.85*	*0.75*	*2.17*	*3.39*
	FISH.														
099	—livers, meal mech extd	5-01-968	93	—	—	—	—	—	—	—	—	—	—	—	—
100			*100*	—	—	—	—	—	—	—	—	—	—	—	—
101	—solubles, condensed	5-01-969	50	1.62	0.74	1.64	1.00	1.87	1.77	0.83	0.98	0.85	0.38	0.40	1.18
102			*100*	*3.21*	*1.47*	*3.26*	*1.99*	*3.71*	*3.50*	*1.64*	*1.94*	*1.69*	*0.75*	*0.78*	*2.34*
103	—solubles, dehy	5-01-971	92	3.15	0.59	1.81	2.09	2.87	3.67	1.17	1.49	1.40	0.59	0.87	2.16
104			*100*	*3.42*	*0.64*	*1.96*	*2.27*	*3.11*	*3.98*	*1.26*	*1.62*	*1.52*	*0.64*	*0.94*	*2.35*
	FLAX. *Linum usitatissimum*														
105	—seeds, meal mech extd	5-02-045	91	2.72	0.58	0.64	1.76	1.88	1.19	0.54	1.41	1.12	0.50	0.89	1.57
106	(Linseed meal)		*100*	*3.00*	*0.64*	*0.71*	*1.94*	*2.07*	*1.31*	*0.60*	*1.55*	*1.24*	*0.55*	*0.99*	*1.73*
107	—seeds, meal solv extd	5-02-048	90	3.07	0.63	0.69	1.64	2.03	1.20	0.59	1.21	1.23	0.52	1.09	1.80
108	(Linseed meal)		*100*	*3.41*	*0.71*	*0.77*	*1.83*	*2.26*	*1.34*	*0.65*	*1.34*	*1.37*	*0.58*	*1.21*	*2.00*
	GRAINS.														
109	—distillers grains, dehy	5-02-144	93	1.06	—	0.59	1.38	2.95	0.82	0.49	1.13	0.90	0.22	0.91	1.37
110			*100*	*1.14*	—	*0.63*	*1.50*	*3.19*	*0.89*	*0.52*	*1.22*	*0.98*	*0.23*	*0.98*	*1.48*
	LIMESTONE.														
111	—grnd	6-02-632	100	—	—	—	—	—	—	—	—	—	—	—	—
112			*100*	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

			As-Fed and Dry Basis (Moisture Free)												
Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	LINSEED. see Flax														
	LIVER. Animal														
113	—meal dehy	5-00-389	93	4.11	0.90	1.50	3.36	5.41	4.81	1.30	2.91	2.61	0.60	1.70	4.21
114			*100*	*4.43*	*0.97*	*1.62*	*3.62*	*5.84*	*5.19*	*1.41*	*3.14*	*2.81*	*0.65*	*1.84*	*4.54*
	MEAT. Animal														
115	—meal rendered	5-00-385	93	3.73	0.65	1.06	1.89	3.44	3.43	0.76	1.93	1.79	0.36	0.87	2.64
116			*100*	*4.02*	*0.70*	*1.14*	*2.03*	*3.70*	*3.69*	*0.82*	*2.07*	*1.93*	*0.38*	*0.94*	*2.84*
117	—w blood, meal tankage	5-00-386	92	3.59	0.46	1.90	1.90	5.09	3.73	0.73	2.43	2.39	0.72	—	3.75
118	rendered		*100*	*3.91*	*0.50*	*2.06*	*2.06*	*5.53*	*4.05*	*0.80*	*2.65*	*2.60*	*0.78*	—	*4.08*
119	—w bone, rendered	5-00-388	93	3.53	0.49	0.90	1.66	3.05	2.98	0.66	1.73	1.69	0.30	0.77	2.38
220			*100*	*3.80*	*0.53*	*0.97*	*1.78*	*3.28*	*3.20*	*0.71*	*1.87*	*1.82*	*0.32*	*0.83*	*2.56*
	MILK. *Bos taurus*														
121	—dehy	5-01-167	96	0.92	—	0.72	1.33	2.56	2.25	0.61	1.33	1.02	0.41	1.33	1.74
122			*100*	*0.96*	—	*0.75*	*1.39*	*2.67*	*2.35*	*0.64*	*1.39*	*1.07*	*0.43*	*1.39*	*1.81*
123	—skimmed dehy	5-01-175	94	1.15	0.44	0.86	2.19	3.31	2.52	0.90	1.58	1.59	0.44	1.13	2.31
124			*100*	*1.23*	*0.47*	*0.92*	*2.34*	*3.54*	*2.69*	*0.96*	*1.69*	*1.69*	*0.47*	*1.21*	*2.46*
	MILLET, FOXTAIL. *Setaria italica*														
125	—grain	4-03-102	89	—	—	—	—	—	—	—	—	—	—	—	—
126			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	MOLASSES.														
127	—beet, sugar, molasses, mt 48%	4-00-668	78	—	—	—	—	—	—	—	—	—	—	—	—
128	invert sugar mt 79.5 degrees brix		*100*	—	—	—	—	—	—	—	—	—	—	—	—
129	—sugarcane, molasses, dehy	4-04-695	90	—	—	—	—	—	—	—	—	—	—	—	—
130			*100*	—	—	—	—	—	—	—	—	—	—	—	—
131	—sugarcane, molasses, mt 48%	4-04-696	75	—	—	—	—	—	—	—	—	—	—	—	—
132	invert sugar mt 79.5 degrees brix		*100*	—	—	—	—	—	—	—	—	—	—	—	—
133	MONO-DICALCIUM PHOSPHATE.	6-26-137	98	—	—	—	—	—	—	—	—	—	—	—	—
134			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	OATS. *Avena sativa*														
135	—cereal by-product, lt 4% fiber	4-03-303	91	0.88	0.25	0.30	0.54	1.08	0.48	0.21	0.70	0.49	0.20	0.75	0.75
136	(Feeding oat meal)		*100*	*0.97*	*0.27*	*0.33*	*0.60*	*1.19*	*0.53*	*0.23*	*0.78*	*0.54*	*0.22*	*0.82*	*0.83*
137	—grain	4-03-309	89	0.65	0.18	0.19	0.42	0.77	0.38	0.14	0.51	0.35	0.15	0.35	0.54
138			*100*	*0.73*	*0.21*	*0.21*	*0.48*	*0.87*	*0.43*	*0.16*	*0.57*	*0.40*	*0.17*	*0.40*	*0.61*
139	—groats	4-03-331	89	0.80	0.20	0.27	0.55	0.99	0.30	0.20	0.62	0.45	0.18	0.60	0.67
140			*100*	*0.89*	*0.22*	*0.31*	*0.61*	*1.11*	*0.33*	*0.22*	*0.70*	*0.50*	*0.20*	*0.67*	*0.75*
141	—hulls	1-03-281	93	0.17	0.06	0.09	0.17	0.28	0.17	0.09	0.17	0.17	0.09	0.17	0.20
142			*100*	*0.19*	*0.07*	*0.09*	*0.19*	*0.30*	*0.19*	*0.09*	*0.18*	*0.18*	*0.09*	*0.19*	*0.22*

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free) Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	OYSTERS. *Crassostrea* spp., *Ostrea* spp.														
143	—shells, grnd fine	6-03-481	99	—	—	—	—	—	—	—	—	—	—	—	—
144	(Oyster shell flour)		*100*	—	—	—	—	—	—	—	—	—	—	—	—
	PEA. *Pisum* spp.														
145	—seeds	5-03-600	89	1.37	0.17	0.70	1.07	1.76	1.56	0.30	1.27	0.92	0.23	—	1.27
146			*100*	*1.54*	*0.19*	*0.79*	*1.21*	*1.98*	*1.76*	*0.34*	*1.43*	*1.03*	*0.26*	—	*1.43*
	PEANUTS. *Arachis hypogaea*														
147	—kernels, meal mech extd	5-03-649	90	4.05	—	0.85	1.70	2.62	1.33	0.50	1.95	1.17	0.47	—	1.89
148	(Peanut meal)		*100*	*4.51*	—	*0.94*	*1.89*	*2.91*	*1.48*	*0.56*	*2.17*	*1.30*	*0.53*	—	*2.11*
149	—kernels, meal solv extd	5-03-650	92	4.62	0.69	0.93	1.69	2.61	1.62	0.42	1.99	1.09	0.47	1.52	1.79
150	(Peanut meal)		*100*	*5.00*	*0.74*	*1.01*	*1.83*	*2.83*	*1.75*	*0.45*	*2.15*	*1.18*	*0.51*	*1.65*	*1.94*
	PHOSPHATE.														
151	—defluorinated, grnd	6-01-780	100	—	—	—	—	—	—	—	—	—	—	—	—
152			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	POTATO. *Solanum tuberosum*														
153	—tubers, dehy	4-07-850	91	—	—	—	—	—	—	—	—	—	—	—	—
154			*100*	—	—	—	—	—	—	—	—	—	—	—	—
	POULTRY.														
155	—by-products, meal rendered	5-03-798	93	3.85	0.91	0.88	2.55	4.14	2.77	1.07	2.31	2.11	0.46	0.90	2.99
156			*100*	*4.13*	*0.98*	*0.94*	*2.73*	*4.44*	*2.97*	*1.15*	*2.48*	*2.27*	*0.50*	*0.97*	*3.21*
157	—feathers, hydrolyzed meal	5-03-795	93	5.44	3.84	0.51	3.56	6.46	1.63	0.48	3.41	3.63	0.52	2.29	6.03
158			*100*	*5.84*	*4.12*	*0.54*	*3.82*	*6.93*	*1.75*	*0.52*	*3.66*	*3.90*	*0.56*	*2.45*	*6.47*
	RICE. *Oryza sativa*														
159	—bran w germ (Rice bran)	4-03-928	91	0.85	0.18	0.32	0.51	0.90	0.57	0.24	0.58	0.47	0.10	0.68	0.76
160			*100*	*0.94*	*0.19*	*0.35*	*0.56*	*0.99*	*0.62*	*0.27*	*0.64*	*0.52*	*0.11*	*0.75*	*0.83*
161	—grain, grnd (Ground rough	4-03-938	89	0.89	0.14	0.19	0.40	0.73	0.34	0.17	0.47	0.31	0.11	0.70	0.56
162	rice)		*100*	*1.00*	*0.16*	*0.22*	*0.44*	*0.82*	*0.38*	*0.19*	*0.53*	*0.35*	*0.12*	*0.79*	*0.63*
163	—groats, polished (Rice,	4-03-942	89	0.44	0.09	0.18	0.45	0.71	0.28	0.25	0.53	0.36	0.09	0.62	0.53
164	polished)		*100*	*0.50*	*0.11*	*0.20*	*0.50*	*0.80*	*0.32*	*0.28*	*0.60*	*0.40*	*0.11*	*0.70*	*0.60*
165	—polishings	4-03-943	90	0.63	0.14	0.19	0.36	0.65	0.53	0.21	0.39	0.35	0.10	0.42	0.73
166			*100*	*0.70*	*0.16*	*0.21*	*0.40*	*0.72*	*0.59*	*0.23*	*0.44*	*0.39*	*0.12*	*0.46*	*0.81*
	RYE. *Secale cereale*														
167	—grain	4-04-047	87	0.54	0.19	0.26	0.47	0.71	0.42	0.16	0.56	0.37	0.13	0.27	0.56
168			*100*	*0.61*	*0.22*	*0.30*	*0.53*	*0.82*	*0.48*	*0.18*	*0.65*	*0.42*	*0.14*	*0.31*	*0.64*
	SEAWEED. Laminariales (order), Fucales (order)														
169	—whole, s-c	1-04-190	89	—	—	—	—	—	—	—	—	—	—	—	—
170			*100*	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free): Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	SESAME. *Sesamum indicum*														
171	—seeds, meal mech extd	5-04-220	93	4.59	0.60	1.16	1.97	3.10	1.25	1.37	2.13	1.60	0.72	1.85	2.36
172			100	4.96	0.65	1.25	2.12	3.34	1.35	1.47	2.30	1.72	0.77	1.99	2.54
	SHRIMP. *Pandalus* spp., *Penaeus* spp.														
173	—cannery residue, meal	5-04-226	90	2.25	0.40	0.70	1.58	2.27	2.02	0.73	1.55	1.47	0.39	—	1.98
174	(Shrimp meal)		100	2.50	0.44	0.78	1.76	2.53	2.25	0.82	1.73	1.64	0.43	—	2.21
175	SODIUM TRIPOLYPHOSPHATE.	6-08-076	—	—	—	—	—	—	—	—	—	—	—	—	—
176	$Na_5P_3O_{10}$		100	—	—	—	—	—	—	—	—	—	—	—	—
	SORGHUM. *Sorghum vulgare*														
177	—grain	4-04-383	90	0.40	0.21	0.24	0.45	1.46	0.25	0.13	0.56	0.37	0.15	0.41	0.53
178			100	0.44	0.23	0.26	0.50	1.62	0.28	0.14	0.63	0.41	0.16	0.46	0.59
	SOYBEAN. *Glycine max*														
179	—seeds, meal mech extd	5-04-600	90	2.96	0.51	1.10	2.81	3.60	2.75	0.67	2.11	1.71	0.62	1.40	2.21
180			100	3.28	0.57	1.22	3.11	3.99	3.05	0.75	2.34	1.89	0.69	1.55	2.45
181	—seeds, meal solv extd	5-04-604	89	2.90	0.74	1.02	2.07	3.29	2.62	0.52	2.12	1.66	0.65	1.27	2.06
182			100	3.25	0.83	1.14	2.32	3.68	2.93	0.58	2.37	1.86	0.73	1.42	2.31
183	—seeds wo hulls, meal solv	5-04-612	90	3.37	0.76	1.15	2.20	3.53	2.96	0.60	2.32	1.84	0.70	1.62	2.17
184	extd		100	3.73	0.84	1.27	2.43	3.91	3.28	0.67	2.56	2.04	0.77	1.79	2.40
	SUGARCANE. *Saccharum officinarium*														
	—molasses—see Molasses														
	SUNFLOWER. *Helianthus* spp.														
185	—seeds wo hulls, meal mech	5-04-738	93	3.46	0.69	0.91	1.91	—	1.92	1.59	1.71	1.45	0.55	—	2.06
186	extd		100	3.73	0.74	0.98	2.07	—	2.08	1.72	1.85	1.57	0.59	—	2.23
187	—seeds wo hulls, meal solv	5-04-739	93	3.56	0.74	1.01	2.02	2.64	1.72	0.91	2.14	1.52	0.58	—	2.30
188	extd		100	3.83	0.80	1.09	2.17	2.84	1.85	0.98	2.30	1.64	0.62	—	2.47
	TOMATO. *Lycopersicon esculentum*														
189	—pomace, dehy	5-05-041	92	1.19	—	0.40	0.70	1.70	1.59	0.10	0.89	0.70	0.20	0.90	0.99
190			100	1.30	—	0.43	0.76	1.85	1.73	0.11	0.97	0.76	0.22	0.98	1.08
	WHALE. *Balaena glacialis*, *Balaenoptera* spp., *Physeter catadon*														
191	—meat, meal rendered	5-05-160	92	2.49	—	1.19	2.72	4.28	4.57	1.65	2.06	1.63	0.82	—	2.81
192			100	2.72	—	1.30	2.97	4.67	5.00	1.80	2.25	1.79	0.89	—	3.07
	WHEAT. *Triticum* spp.														
193	—bran	4-04-190	89	1.03	0.35	0.40	0.49	0.93	0.60	0.21	0.57	0.47	0.28	0.44	0.70
194			100	1.16	0.39	0.46	0.55	1.05	0.68	0.23	0.64	0.53	0.32	0.49	0.78
195	—flour, lt 2% fiber	4-05-199	87	0.42	0.31	0.25	0.46	0.88	0.24	0.18	0.60	0.32	0.10	0.33	0.49

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	As-Fed and Dry Basis (Moisture Free) Agri-nine (%)	Cys-tine (%)	His-ti-dine (%)	Iso-leu-cine (%)	Leu-cine (%)	Ly-sine (%)	Me-thio-nine (%)	Phen-ylal-a-nine (%)	Thre-o-nine (%)	Tryp-to-phan (%)	Tyro-sine (%)	Val-ine (%)
196			*100*	*0.48*	*0.36*	*0.29*	*0.52*	*1.01*	*0.27*	*0.21*	*0.68*	*0.37*	*0.11*	*0.38*	*0.56*
197	—germs, grnd (Wheat germ	5-05-218	88	1.88	0.47	0.65	0.88	1.56	1.54	0.44	0.94	0.97	0.30	0.73	1.17
198	meal)		*100*	*2.14*	*0.53*	*0.74*	*1.00*	*1.77*	*1.74*	*0.50*	*1.07*	*1.10*	*0.34*	*0.83*	*1.33*
199	—grain	4-05-211	88	0.58	0.31	0.28	0.47	0.87	0.37	0.18	0.61	0.38	0.16	0.41	0.56
200			*100*	*0.66*	*0.35*	*0.31*	*0.53*	*0.98*	*0.42*	*0.21*	*0.69*	*0.43*	*0.18*	*0.46*	*0.64*
201	—grain, hard red spring	4-05-258	88	0.59	0.25	0.23	0.56	0.87	0.35	0.19	0.66	0.36	0.14	0.50	0.59
202			*100*	*0.67*	*0.28*	*0.26*	*0.64*	*1.00*	*0.40*	*0.21*	*0.75*	*0.41*	*0.16*	*0.58*	*0.67*
203	—grain, hard red winter	4-05-268	88	0.61	0.31	0.28	0.51	0.88	0.36	0.21	0.63	0.38	0.18	0.43	0.59
204			*100*	*0.69*	*0.35*	*0.31*	*0.58*	*1.00*	*0.41*	*0.24*	*0.71*	*0.43*	*0.20*	*0.49*	*0.67*
205	—grain, screenings	4-05-216	89	—	—	—	—	—	—	—	—	—	—	—	—
206			*100*	—	—	—	—	—	—	—	—	—	—	—	—
207	—grain, soft red winter	4-05-294	88	0.55	0.30	0.24	0.45	0.90	0.50	0.22	0.64	0.39	0.26	0.38	0.57
208			*100*	*0.62*	*0.34*	*0.27*	*0.51*	*1.02*	*0.57*	*0.24*	*0.72*	*0.44*	*0.30*	*0.43*	*0.65*
209	—grain, soft white winter	4-05-337	88	0.46	0.27	0.22	0.40	0.65	0.31	0.16	0.45	0.31	0.12	0.36	0.45
210			*100*	*0.52*	*0.30*	*0.24*	*0.46*	*0.73*	*0.35*	*0.18*	*0.51*	*0.35*	*0.14*	*0.41*	*0.50*
211	—grits	4-07-852	90	—	—	—	—	—	—	—	—	—	—	—	—
212			*100*	—	—	—	—	—	—	—	—	—	—	—	—
213	—middlings, lt 9.5 fiber	4-05-205	89	0.87	0.22	0.36	0.70	1.09	0.67	0.20	0.64	0.53	0.22	0.39	0.77
214			*100*	*0.98*	*0.25*	*0.40*	*0.79*	*1.22*	*0.76*	*0.23*	*0.72*	*0.59*	*0.24*	*0.43*	*0.86*
215	—mill run, lt 9.5% fiber	4-05-206	90	0.90	0.20	0.40	0.70	1.20	0.50	0.40	—	0.50	0.20	0.50	0.80
216			*100*	*1.00*	*0.22*	*0.44*	*0.78*	*1.33*	*0.56*	*0.44*	—	*0.56*	*0.22*	*0.56*	*0.89*
217	—red dog, lt 4.5% fiber	4-05-203	88	0.96	0.38	0.38	0.54	1.05	0.58	0.24	0.65	0.50	0.19	0.46	0.72
218			*100*	*1.10*	*0.43*	*0.43*	*0.62*	*1.19*	*0.66*	*0.27*	*0.74*	*0.57*	*0.22*	*0.52*	*0.82*
219	—shorts, lt 7% fiber	4-05-201	88	1.21	0.38	0.45	0.57	1.09	0.81	0.28	0.67	0.60	0.23	0.49	0.83
220			*100*	*1.38*	*0.43*	*0.51*	*0.65*	*1.24*	*0.92*	*0.32*	*0.76*	*0.68*	*0.27*	*0.56*	*0.94*
	WHEAT, DURUM. *Triticum durum*														
221	—grain	4-05-224	87	0.66	—	0.34	0.58	1.04	0.38	0.18	0.80	0.42	—	0.39	0.69
222			*100*	*0.76*	—	*0.39*	*0.67*	*1.20*	*0.43*	*0.21*	*0.92*	*0.48*	—	*0.44*	*0.79*
	WHEY. *Bos taurus*														
223	—dehy	4-01-182	93	0.33	0.29	0.17	0.81	1.18	0.92	0.18	0.35	0.87	0.17	0.25	0.68
224			*100*	*0.35*	*0.31*	*0.19*	*0.87*	*1.27*	*0.98*	*0.20*	*0.37*	*0.93*	*0.18*	*0.27*	*0.73*
225	—low lactose, dehy (Dried	4-01-186	93	0.68	0.49	0.26	0.84	1.17	1.43	0.42	0.51	0.82	0.28	0.46	0.76
226	whey product)		*100*	*0.73*	*0.53*	*0.27*	*0.90*	*1.26*	*1.53*	*0.45*	*0.55*	*0.88*	*0.30*	*0.50*	*0.82*
	YEAST. *Candida utilis*														
227	—petroleum, solv extd dehy	7-09-836	92	2.04	0.46	0.89	2.48	3.61	3.59	0.82	2.22	3.00	0.41	1.78	2.66
228			*100*	*2.22*	*0.50*	*0.99*	*2.70*	*3.92*	*3.90*	*0.89*	*2.41*	*3.26*	*0.45*	*1.93*	*2.89*

TABLE 11 Amino Acid Composition of Some Common Fish Feeds—Continued

				As-Fed and Dry Basis (Moisture Free)												
Line No.	SCIENTIFIC NAME Short Name	International Feed No.[a]	Dry Matter (%)	Arginine (%)	Cystine (%)	Histidine (%)	Isoleucine (%)	Leucine (%)	Lysine (%)	Methionine (%)	Phenylalanine (%)	Threonine (%)	Tryptophan (%)	Tyrosine (%)	Valine (%)
	YEAST. *Saccharomyces cerevisiae*														
229	—brewers, dehy	7-05-527	93	2.22	0.51	1.11	2.17	3.24	3.11	0.73	1.83	2.10	0.51	1.52	2.34
230			*100*	*2.37*	*0.55*	*1.19*	*2.32*	*3.46*	*3.33*	*0.78*	*1.96*	*2.25*	*0.55*	*1.62*	*2.50*
231	—primary, dehy	7-05-533	93	2.60	0.50	5.60	3.60	3.70	3.80	1.00	2.50	2.50	0.40	—	3.20
232			*100*	*2.81*	*0.54*	*6.05*	*3.89*	*4.00*	*4.10*	*1.08*	*2.70*	*2.70*	*0.43*	—	*3.46*
	YEAST. *Torulopsis utilis*														
233	—torula, dehy	7-05-534	93	2.60	0.60	1.40	2.90	3.50	3.80	0.80	3.00	2.60	0.50	2.10	2.90
234			*100*	*2.80*	*0.65*	*1.51*	*3.12*	*3.77*	*4.09*	*0.86*	*3.23*	*2.80*	*0.54*	*2.26*	*3.12*

[a] The first digit is the feed class: (1) dry forages and roughages; (2) pasture, range plants, and forages fed green; (3) silages; (4) energy feeds; (5) protein supplements; (6) minerals; (7) vitamins; (8) additives.

TABLE 12 Protein Digestion Coefficients for Fish Feeds

Test Fish Name of Feed	International Feed No.	Digestion Coefficient (%)
Carp. *Cyprinus carpio*		
Barley, grain	4-00-549	81
Barley, grain (Summer barley)	4-00-549	64
Casein, dehy	5-01-162	99[a]
Casein, dehy	5-01-162	96[b]
Cattle, livers, dehy	5-10-102	89-93
Cattle, livers, fresh	5-01-166	83-90
Gelatin, process residue	5-14-503	97[a]
Chicken, egg yolk, dehy	5-01-211	95[a]
Corn, gluten meal	5-02-900	91[a]
Corn, dent yellow, grain	4-02-935	66
Fish, white, meal mech extd	5-02-025	95[a]
Lupine, sweet yellow, seeds	5-08-458	85
Oats, grain	4-03-309	64
Peanuts, kernels, meal solv extd	5-03-650	85
Peas, seeds	5-03-600	79
Rye, grain	4-04-047	63
Silkworm, pupa, dehy	5-11-787	93[b]
Soybean, seeds, meal solv extd	5-04-604	81-96
Trout pellet food	—	93
Whale, blood meal	5-20-942	95[b]
Wheat, germ, meal	5-05-218	97
Wheat, grain	4-05-211	84
Yeast, petroleum A	7-20-957	87
Yeast, petroleum B	7-20-958	91
Yeast, petroleum C	7-20-959	91
Yeast, petroleum D	7-20-960	94
Goldfish. *Carassius auratus*		
Alfalfa, meal dehy	1-00-025	66
Gelatin, process residue	5-14-502	93[b]
Chlorella, whole, dehy	5-07-747	26-58[b]
Corn, gluten meal	5-02-900	96[b]
Fish, white, meal mech extd	5-02-025	92
Silkworm, pupa, dehy	5-11-787	80[b]
Silkworm, pupa, solv extd	5-20-950	87
Catfish, channel. *Ictalurus punctatus*		
Alfalfa, hay, meal s-c	1-00-111	13
Blood, meal, dehy	5-00-380	23
Corn, gluten, meal	5-02-900	80
Corn, dent yellow, grain	4-02-935	60
Corn, dent yellow, grain, boiled, dehy	4-02-853	66
Corn, distillers solubles, dehy	5-02-844	67
Cotton, seeds, meal solv extd	5-01-619	76-83
Fish, meal mech extd	5-01-977	85[b]
Fish, anchovy, meal mech extd	5-01-985	87-90
Fish, herring, meal mech extd	5-02-000	80
Fish, menhaden, meal mech extd	5-02-009	74
Fish, menhaden, meal mech extd	5-02-009	80-89[b]
Meat meal, rendered	5-00-385	42
Meat w bone, meal rendered	5-00-388	75
Poultry, feathers, hydrolyzed meal	5-03-795	74
Poultry, offal w feathers, meal rendered	5-13-540	27

TABLE 12 Protein Digestion Coefficients for Fish Feeds—Continued

Test Fish Name of Feed	International Feed No.	Digestion Coefficient (%)
Rice, bran w germ	4-03-928	71
Sorghum, gluten, meal	5-04-388	41
Soybean, seeds, meal solv extd	5-04-604	72-84
Soybean, seeds, grnd	5-04-596	31
Soybean, seeds, grnd	5-04-596	30[b]
Wheat, grain	4-05-211	82
Wheat, shorts lt 7% fiber	4-05-201	72
Eel. *Anguilla japonica*		
Fish, saury, whole, fresh	5-20-938	94
Fish, saury, whole, fresh	5-20-938	90-92[b]
Fish, white, meal mech extd	5-02-025	80-85[b]
Plaice. *Pleuronectes platessa*		
Yeast, BP (British Petroleum) protein	5-20-948	90[b]
Fish, protein concentrate	5-09-334	96[b]
Fish, cod, flesh, freeze dehy	5-20-940	91[b]
Fish, white, meal mech extd	5-02-025	86[b]
Soybean, seeds, meal mech extd	5-04-600	68[b]
Yellowtail. *Seriola* spp.		
Eel, sand, whole, fresh	5-20-939	98
Eel, sand, whole, fresh	5-20-939	77-91[b]
Fish, mackerel, horse, meal mech extd	5-20-944	63-91[b]
Fish, white, meal mech extd	5-02-025	22-83[b]
Red sea bream. *Chysophrys major*		
Fish, white, meal mech extd	5-02-025	61-87[b]
Soybean, seeds wo hulls, meal solv extd	5-04-612	78[b]
Sea bream. *Siganus fuscescens, Evynnis japonica*		
Fish, white, meal mech extd	5-02-025	67-79[b]
Soybean, seeds wo hulls, meal solv extd	5-04-612	74-78[b]
Prawn. *Palaemon serratus*		
Casein, dehy	5-01-162	98
Gelatin, process residue	5-14-503	98
Chicken, eggs, freeze dehy	5-20-946	94
Chicken, egg white, dehy	5-01-209	97
Corn, gluten, meal	5-02-900	93
Cotton, seeds, meal solv extd	5-01-619	82
Fish, anchovy, meal mech extd	5-01-985	82
Fish, herring, meal mech extd	5-02-000	89
Fish, white, meal mech extd	5-02-025	91
Animal, by-product, meal rendered (Dried slaughter house offal)	5-08-786	83
Mussel, meat w liquid, freeze dehy	5-20-947	91
Peanut, kernels, meal solv extd (Groundnut meal)	5-03-650	90
Shrimp, cannery residue, meal	5-04-226	88

TABLE 12 Protein Digestion Coefficients for Fish Feeds—Continued

Test Fish Name of Feed	International Feed No.	Digestion Coefficient (%)
Soybean, seeds, meal solv extd	5-04-604	94
Whale, meat, meal rendered	5-05-160	80
Yeast, BP (British Petroleum) protein	5-20-958	95
Prawn. *Pandulus platyceros*		
Casein, dehy	5-01-162	97
Fish, white, meal mech extd	5-02-025	75
Shrimp, cannery residue, meal	5-04-226	82
Soybean, seeds, meal solv extd	5-04-604	89
Yeast, BP (British Petroleum) protein	5-20-958	94
Prawn. *Penaeus japonicus*		
Algae, diatom, whole, fresh	5-20-948	63[b]
Fish, white, meal mech extd	5-02-025	58-88[b]
Sea lettuce, stems, fresh	2-11-981	16[b]
Shrimp, whole, fresh	5-20-949	86[b]
Crayfish. *Procambarus clarkii*		
Casein dehy (54% mixture w 15% gelatin, process residue)	5-01-162 (5-14-503)	91-97[b]
Chicken, egg white, dehy	5-01-209	95[b]
Chicken, egg white, dehy (54% mixture w 15% gelatin, process residue)	5-01-209 (5-14-503)	91-99[b]

[a]True digestion coefficient.
[b]The main protein source listed when present in mixtures.

TABLE 13 Carbohydrate Digestion Coefficients for Fish Feeds

Test Fish Name of Feed	International Feed No.	Digestion Coefficient (%)
Carp. *Cyprinus carpio*		
Potato, alpha, starch	4-20-962	84-85[a]
Potato, beta, starch	4-20-963	52-60[a]
Catfish, channel. *Ictalurus punctatus*		
Alfalfa, meal dehy	1-00-025	12[a]
Glucose	4-02-891	88-92[a]
Corn, dextrin	4-20-945	48-73[a]
Corn, dent yellow, grain	4-02-935	59-66[a]
Corn, dent yellow, grain, boiled dehy	4-02-853	62-78[a]
Cotton, seed, meal solv extd	5-01-619	17[a]
Wheat, grain	4-05-211	59[a]
Eel. *Anguilla japonica, Anguilla anguilla*		
Potato, alpha, starch	4-20-962	78-98[a]
Wheat, grain	4-05-211	52[a]
Wheat, grain, boiled	4-05-209	88[a]
Yellowtail. *Seriola* spp.		
Corn, alpha, starch	4-20-964	32[a]
Corn, dextrin	4-20-945	57[a]
Potato, alpha, starch	4-20-962	21-43[a]
Sea bream. *Evynnis japonica*		
Glucose	4-02-891	58-75[a]

[a]Present in mixture with other feedstuff.

TABLE 14 Lipid Digestion Coefficients for Fish Feeds

Test Fish Name of Feed	International Feed No.	Temperature of Water[a] (° C)	Digestion Coefficient (%)
Catfish, channel, *Ictalurus punctatus*			
Alfalfa, meal dehy	1-00-025	—	51
Corn, dent yellow, grain	4-02-935	—	76
Corn, dent yellow, grain, boiled	4-02-853	—	96
Cotton seeds, meal solv extd	5-01-619	—	81-94
Fats and oils, oil, fish	7-01-965	—	97
Fish, meal mech extd	5-01-977	—	97
Fish, meal mech extd	5-01-977	—	95[b]
Meat w bone, meal rendered	5-10-111	—	77
Poultry, feathers, hydrolyzed meal	5-03-795	—	83
Soybean, seeds, meal solv extd	5-04-604	—	81
Wheat, grain	4-05-211	—	96
Wheat, shorts, lt 7% fiber	4-05-201	—	90
Carp. *Cyprinus carpio*			
Fats and oils, oil, coconut	4-09-320	25	90
Fats and oils, liver oil, pollack	7-20-954	25	91-94
Fats and oils, liver oil, pollack	7-20-954	15	91
Fats and oils, oil, soybean	4-07-983	25	89
Fats and oils, oil, soybean	4-07-983	15	90
Fats and oils, fat, swine	4-04-790	25	78
Fats and oils, fat, swine	4-04-790	15	77

[a]Water temperature data not available for lipid digestibility by channel catfish.
[b]The main lipid source listed when present in mixtures.

TABLE 15 Abbreviations for Terms Used in Tables 10, 11, 12, 13, and 14

dehy	dehydrated
extd	extracted
g	gram
gr	grade
grnd	ground
IU	International Units
kcal	Kilocalories
kg	kilogram(s)
lt	less than
mech extd	mechanically extracted expeller extracted, hydraulic extracted, or old process
μg	microgram
mg	milligram
mt	more than
s-c	suncured
solv extd	solvent extracted
spp.	species
w	with
wo	without

TABLE 16 Description of How Short Names Are Formed

Components of Name	Feed No. 1	Feed No. 2	Feed No. 3
Origin (or parent material)	Clover	Soybean	Wheat
Species, variety, or kind	red		soft white winter
Part eaten	hay	seeds	grain
Process(es) and treatment(s) undergone before fed to animal	s-c	meal solv extd	
Grade or quality designations		44% protein	
Classification; first digit is international feed number (IFN)	(1) (dry forages and roughages)	(5) (protein supplements)	(4) (energy feeds)
IFN	1-01-415	5-20-637	4-05-337

TABLE 17 Weight-Unit Conversion Factors

Units Given	Units Wanted	For Conversion Multiply by	Units Given	Units Wanted	For Conversion Multiply by
lb	g	453.6	μg/kg	μg/lb	0.4536
lb	kg	0.4536	Mcal	kcal	1,000
oz	g	28.35	kcal/kg	kcal/lb	0.4536
kg	lb	2.2046	kcal/lb	kcal/kg	2.2046
kg	mg	1,000,000	ppm	μg/g	1
kg	g	1,000	ppm	mg/kg	1
g	mg	1,000	ppm	mg/lb	0.4536
g	μg	1,000,000	mg/kg	%	0.0001
mg	μg	1,000	ppm	%	0.0001
mg/g	mg/lb	453.6	mg/g	%	0.1
mg/kg	mg/lb	0.4536	g/kg	%	0.1

TABLE 18 Weight Equivalents

1 lb = 453.6 g = 0.4536 kg = 16 oz
1 oz = 28.35 g
1 kg = 1,000 g = 2.2046 lb
1 g = 1,000 mg
1 mg = 1,000 μg = 0.001 g
1 μg = 0.001 mg = 0.000001 g
1 μg per g or 1 mg per kg is the same as ppm

APPENDIX A: TEST DIETS

TABLE A-1 Purified or Vitamin Test Diet for Catfish

Ingredient	International Feed No.	Amount in Diet (%)
Casein, vitamin free	5-20-679	30
Corn, dextrin	4-20-945	10
Soybean, oil[a]	4-07-983	10
Vitamin mixture[b]	—	3
Mineral mixture[c]	—	4
Cellulose, flour	8-20-966	40
Carboxymethylcellulose	8-20-967	3

[a]Substitute fish oil for one-half of the soybean oil in studies not involving vitamin test.
[b]Use the complete vitamin premix, Table 6, p. 18.
[c]Use the mineral mixture, Table 8, p. 22.

Instructions for Preparation:

The diet is prepared by placing the vitamins, oil, and carboxymethylcellulose (CMC) in a weight of hot (80° C) water equal to the total weight of the ingredients in the diet. The vitamin-oil-CMC mixture is mechanically stirred for 5–10 min until the CMC is dissolved and the ingredients are thoroughly mixed. The remaining ingredients are then added and thoroughly mixed. The prepared diet is refrigerated or frozen until fed.

TABLE A-2 Amino Acid Test Diet for Catfish

Ingredient	International Feed No.	Amount in Diet (%)
Amino acid mixture[a]	—	33
Corn, dextrin	4-20-945	20
Cellulose, powdered (flour)	8-20-966	20
Corn, oil	4-07-882	7
Fish, oil	7-01-965	4
Carboxymethylcellulose	8-20-967	10
Vitamin mixture[a]	—	4
Mineral mixture[b]	—	2

[a]Amino acid mixture (L-isomer) per 100 g dry mixture:

Arginine	2.4	Tryptophan	0.5
Histidine	1.2	Tyrosine	1.9
Isoleucine	1.9	Valine	1.9
Leucine	2.8	Glycine	3.5
Lysine	2.4	Alanine	1.7
Methionine	0.9	Aspartic acid	2.4
Phenylalanine	1.9	Cystine	0.3
Threonine	1.2	Glutamic acid	3.8
		Proline	2.3

[b]Use the complete vitamin premix, Table 6, p. 18.
[c]Use the mineral mixture, Table 8, p. 22.

Instructions for Preparation:

The diet is prepared by placing the amino acid mixture and salt mixture in a weight of hot water (80° C) equal to the total weight of the ingredients in the diet. The water amino acid-salt mixture is mechanically stirred for approximately 30 min or until the amino acids are thoroughly wet, and then the pH of the mixture is adjusted to 6.8 with 20 percent sodium hydroxide. Care is taken to add the sodium hydroxide drop by drop in the area of most agitation to expose the amino acids to strong base for the shortest possible periods. After adjustment of the pH of the amino acids-salt-water mixture, CMC, corn oil and vitamins are added and thoroughly blended with a food mixer. Remaining ingredients are then added and thoroughly mixed. The prepared diet is refrigerated or frozen until fed.

TABLE A-3 Amino Acid Test Diet for Eel

Ingredient	International Feed No.	Amount in Diet (%)
Amino acid mixture[a]	—	46.7
Corn, dextrin	4-20-945	14.0
Corn, oil	4-07-882	5.3
Fish, cod, liver oil	7-01-993	2.7
Mineral mixture[b]	—	6.7
Vitaminized cellulose powder[c]	—	14.6
Carboxymethylcellulose	—	10.0
TOTAL		100.0
Water (ml/100 g air dry mixture)		100.0

[a] Amino acid mixture (L-isomer) per 100 g air dry mixture:

Arginine	2.67	Tryptophan	0.67
Histidine HCl·H_2O	1.33	Valine	3.00
Isoleucine	2.67	Alanine	3.00
Leucine	4.00	Aspartic acid	5.00
Lysine HCl	3.34	Cystine	0.67
Methionine	1.33	Glutamic acid	6.67
Phenylalanine	2.33	Glycine	3.34
Threonine	2.00	Proline	2.67
		Tyrosine	2.00

[b] Mineral mixture (g):

USP XII, salt mixture No. 2	100.0	$MnSO_4 \cdot H_2O$	0.080
$AlCl_3 \cdot 6H_2O$	0.018	$CoCl_2 \cdot 6H_2O$	0.105
KI	0.017	$ZnSO_4 \cdot H_2O$	0.357
$CuCl_2$	0.011		

[c] Vitamin premix added to cellulose powder to make 14.6 g total:

Choline chloride	800	Thiamine hydrochloride	6
Inositol	400	Folic acid	1.5
Ascorbic acid	200	Biotin	0.6
Niacin	80	Vitamin B_{12}	0.009
Calcium pantothenate	28	Alpha-tocopherol	40
Riboflavin	20	Beta-carotene	1.2
Menadione	4	Activated	
Pyridoxine hydrochloride	4	7-dehydrocholesterol	0.0045

Instructions for Preparation:

All dry ingredients are blended with the oils for 5 min. The water that contains adequate sodium hydroxide is added to adjust the pH to 6.8, and the mixture is stirred until it becomes a homogeneous paste. The prepared diet is refrigerated or frozen until fed.

APPENDIX B: PRACTICAL DIETS

TABLE B-1 Thirty-Six-Percent-Protein Pond Fish Diet (Stuttgart Formula)

		Diet Number	
Ingredient	International Feed No.	1 (kg)	2 (kg)
Fish, menhaden, meal mech extd, 60% protein	5-20-969	12.0	—
Fish, herring, meal mech extd, 70% protein	5-20-968	—	10.0
Blood, meal, 80% protein[a]	5-20-970	5.0	5.0
Poultry, feathers, hydrolyzed meal[a]	5-03-795	5.0	5.0
Soybean, seeds wo hulls, meal solv extd, 49% protein	5-20-638	20.0	20.0
Cotton, seeds wo hulls, meal solv extd, 50% protein	5-20-412	10.0	10.0
Corn, distillers solubles	5-02-147	8.0	10.0
Fermentation solubles, dehy	5-02-150	8.0	10.0
Rice, bran w germ (rice bran)	5-02-000	25.0	25.0
Rice, hull fines	4-03-928	—	10.0
Rice milldust or other organic dust passing a U.S. number 80 mesh screen[b]	—	10.0	—
Alfalfa, meal dehy, 17% protein	1-00-023	3.5	3.5
Salt, trace mineral with iodine	—	1.0	1.0
Vitamin premix, complete[c]	—	0.5	0.5

[a] Blood, meal (IFN 5-00-380), or Poultry, feathers, hydrolized, meal (IFN 5-03-795), may be used interchangeably.
[b] Wheat, shorts, lt 7% fiber (IFN 4-05-201); Wheat, middlings, lt 9.5% fiber (IFN 4-05-205); Cereal, grains; Vegetable, oil (IFN 4-05-077); or Fish, whole, oil (IFN 7-01-965); and a pellet binder may be used for rice by-products.
[c] Use the vitamin premix, Table 6, p. 18, for complete or supplemental fish diet.

Guaranteed Analysis of Complete Formula (%):

Crude protein, more than	36 (6.26 × % nitrogen)
Animal protein, more than	15
Crude fiber, less than	12
Ether extract, more than	5

TABLE B-2 Thirty-Six Percent-Protein Catfish Formula (Pelleted or Extruded)[a] (Auburn Number 4)

Ingredient	International Feed No.	Amount in Diet (%)
Soybean, seeds, meal solv extd, 44% protein[b]	5-20-637	45
Wheat, grain, grnd	4-05-211	22
Wheat middlings, lt 9.5% fiber	4-05-205	10
Fish, meal mech extd, 60% protein	5-01-981	9
Corn, distillers solubles, dehy	5-02-147	7.5
Fat, animal	—	2.5
Organic pellet binder[c]	—	2.5
Dicalcium phosphate	6-01-080	1.0
Vitamin premix[d]	—	0.5
Trace mineral premix[e]	—	0.08

[a] For extrusion processing, the pellet binder should be replaced with an equal amount of cereal grain, and the fat- and heat-labile vitamins should be added onto the surface after extrusion.
[b] 6.25 × percent nitrogen.
[c] Hemicellulose or lignin sufonate products.
[d] Use the vitamin premix, Table 6, p. 18, for a complete or supplemental diet.
[e] Trace mineral premix should contain the following (mg per kg): Mn, 115; I, 2.8; Cu, 4.32; Zn, 88.6; Fe, 44.

TABLE B-3 Thirty-Two-Percent-Protein Catfish Formula for High-Density Culture in Raceways, Tanks, and Cages (Skidaway)

Ingredient	International Feed No.	Amount in Diet (%)
Fish, menhaden, meal mech extd, 60% protein[a]	5-02-009	10.00
Corn, gluten, meal, 41% protein[a]	5-20-411	20.00
Soybean, seeds, solv extd, 44% protein[a]	5-20-637	35.00
Corn, dent, yellow, grain	4-02-935	28.95
Cattle, tallow	4-07-880	2.50
Dicalcium phosphate	6-21-516	3.00
Sodium chloride	—	0.25
Vitamin premix[a]	—	0.25
Trace mineral premix[c]	—	0.05

[a]6.25 × percent nitrogen.
[b]Use the vitamin premix, Table 6, p. 18, for a complete or supplemental fish diet.
[c]Mineral mixture: add to cellulose powder to make 0.05 percent of the diet (mg/kg):

Copper	5
Iron	100
Manganese	10
Zinc	25
Iodine	0.25
Cobalt	0.25

TABLE B-4 Twenty-Five-Percent-Protein[a] Catfish Pond Formula, Pelleted (Kansas Z-14)

Ingredient	International Feed No.	Amount in Diet (%)
Wheat, bran	4-05-190	40.5
Sorghum, grain	4-04-383	17.5
Alfalfa, meal, s-c	1-00-025	10.0
Fish, meal mech extd	5-01-976	8.8
Soybean, meal, solv extd	5-04-604	8.5
Meat and bone meal (meat and bone scraps)	5-00-388	6.6
Corn, distillers solubles, dehy	5-02-147	5.0
Blood, meal	5-00-380	1.9
Dicalcium phosphate	6-01-080	0.57
Salt	6-04-152	0.5
Methionine, DL	—	0.09
Vitamin premix[b]	—	0.13

[a]6.25 × percent nitrogen.
[b]Use the vitamin premix, Table 6, p. 18, for a complete or supplemental fish diet.

TABLE B-5 Forty-Six Percent Protein Eel Grower Diet

Ingredients of Air-Dry Feed Mixture	International Feed No.	Diet Number 1 (%)	2 (%)	3 (%)
Fish, meal mech extd, 65% protein[a]	5-01-982	69	67	62
Potato, starch, boiled, dehy	4-03-783	20	24	22
Soybean, seeds, meal solv extd	5-04-604	—	—	5
Yeast, brewers, or	7-05-527	3	3	4
Yeast, torula	7-05-534	—	—	—
Liver, meal, or	5-00-389	2	1	2
Milk, skimmed, dehy	5-01-175	—	—	—
Vitamin premix[b]	—	1	2	2
Mineral premix[c]	—	2	2	2
Others[d]	—	3	1	1

[a]6.25 × percent nitrogen.
[b]One-fifth the amounts of each vitamin shown in the eel amino acid test diet is recommended (Table A-3, p. 66).
[c]Use the mineral mixture shown in Table A-3 (p. 66).
[d]Use the following as attractants and binders:

	IFN
Synthetic flavor	—
Cellulose, carboxymethyl, powdered	8-20-967
Corn, gluten, meal	5-02-900
Blood, meal	5-00-380

A Standard for Chemical Composition:

The recommended composition of an air-dry feed mixture for yearlings is as follows:

Dry matter	more than 90.0%
Ether extract	less than 6.0%
Crude fiber	less than 0.7%
Ash	less than 17.0%
Total nitrogen	more than 7.2%
Total sugar	less than 25.0%

Preparation:

From 80 to 100 parts of water and 5 to 10 parts of oil (usually Fish, pollack, liver, oil, IFN 7-20-954) are added to 100 parts of air-dry feed mixture and blended vigorously for 30 s in a blender.

TABLE B-6 Forty-Percent-Protein Carp Grower Diet (Saku)

Ingredient	International Feed No.	Amount in Diet (%)
Fish, meal mech extd, 65% protein[a]	5-01-982	46
Wheat, middlings, lt 9.5% fiber	4-05-205	28
Rice, bran w germ, meal solv extd	4-03-930	7
Wheat, bran	4-05-190	5
Soybean, seeds, meal solv extd, 44% protein[a]	5-20-637	5
Yeast, torula, dehy	7-05-534	4
Corn, gluten, meal	5-02-900	1.5
Vitamin premix[b]	—	0.5
Mineral premix[c]	—	0.5
Sodium chloride	—	0.5
Potassium phosphate	—	2.0

[a] 6.25 × percent nitrogen.
[b] Vitamin premix: vitamins added to cellulose powder to make 0.5% of diet (mg/kg):

Choline chloride	500
Ascorbic acid	80
Inositol	80
Niacin	60
Calcium pantothenate	80
Vitamin E	45
Riboflavin	25
Pyridoxine	8
Thiamine hydrochloride	5
Biotin	0.05
Vitamin A	8,000 (IU/kg)
Vitamin D_3	1,500 (IU/kg)

[c] Mineral premix: added to cellulose powder to make 0.5% of the diet (mg/kg):

Manganese	25
Iron	10
Zinc	25
Magnesium	250
Cobalt	3

TABLE B-7 Aquarium Fish Food Formula, Flaked[a] (Auburn)

Ingredient	International Feed No.	Amount in Diet (%)
Shrimp, cannery residue, meal	5-04-226	27.00
Fish, meal mech extd	5-01-977	24.40
Soybean, seeds wo hulls, meal solv extd	5-04-612	23.40
Grains:		11.50
Corn, dent yellow, grain	4-02-935	
or		
Oats, cereal by-product, lt 4% fiber (Oat middlings or feeding oat meal	4-03-303	
or		
Oats, grain	4-03-309	
or		
Rice, polishings	4-03-943	
or		
Wheat, grain	4-05-211	
Wheat, bran	4-05-190	9.00
Fish, oil	7-01-965	4.00
Vitamin premix (except for ascorbic acid)[b]	—	0.50
Ethylcellulose-coated ascorbic acid		0.05
Marigold, aztec, flowers, meal and extract[c]	8-05-696	0.13
Ethoxyquin antioxidant	8-01-841	0.20

[a] Processed on drum drying equipment.
[b] Use the vitamin premix, Table 6, p. 18, for a complete fish diet.
[c] Pigment concentrate contains 20 g of xanthophyll per kg; should provide 25 mg of xanthophyll per kg of diet.

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