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POULTRY: FEEDS AND NUTRITION

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Foreword

Agriculture is the world's biggest and most vital industry. The job of agriculture is to produce food to satisfy the nutritional requirements of the population. United States agriculture is the envy of most nations in the world. Of course, the United States is blessed with the land, animals, equipment, skill and the incentive to produce abundant food supplies efficiently. Industrialization of traditional agriculture production in the United States has resulted in all the food that is necessary for growing populations and a variety of nutritious foods at a price most people can pay. A small portion of disposable income is required for food. Agricultural scientists have worked diligently to give agriculture important tools in achieving new dimensions of efficiency. In contrast, Soviet farm output is 30% less than in the United States, even though their planted acreage is 75% greater and their farm labor force far outnumbers that of the United States.

The commercial feed industry and animal agriculture play unique roles in the U.S. economy. Millions of tons of animal feeds are produced annually by the commercial feed industry. This is a vital factor in the production efficiency of U.S. livestock and poultry producers. The United States could not have attained the abundant supply of high protein foods and the production efficiency of animal agriculture without the commercial feed industry. Animal agriculture's production is geared almost directly to consumer demand.

The world's livestock population is at least twice that of the human race. The food industry provides an inventory-free pipeline of abundant food production. It is founded on research that has developed an amazing variety of feed formulations to produce maximum efficiency in the production of meat, milk, and eggs. The commercial broiler industry that came of age in the mid 1940's is an excellent example of the feed industry's contribution to animal agriculture. Broilers used to require 5 lb of feed to gain 1 lb in weight and it took approximately 15 weeks for them to reach a 3-lb market weight. Today, broilers require half that amount of feed and time.

Properly processed soybean meal has given U.S. animal agriculture a foundation for production efficiency unmatched anywhere else in the world. This is indeed one of the most spectacular chapters in the story of modern civilization.

Animal foods are expensive compared to nonanimal foods and must be

justified. Good crop land will produce 10 to 20 times the amount of human food that can be obtained by utilization of animals produced on the same area of land. At best, only a fourth of the protein in the edible parts of plants is returned as meat. A dairy cow is the most efficient converter (28%) and the beef cow the least efficient (6%) in converting plant protein into animal protein. The broiler, laying hen, and swine are intermediate with 22, 22, and 16% efficiencies, respectively. Alfalfa and soybean crops are the leading protein producers. High-protein cereal grains of the better balanced amino acid content, especially lysine, will have an impact on animal proteins and high-protein, oil-bearing seeds within the next decade.

Food resources are most limited in nations that are experiencing the greatest pressure from population expansion. Protein insufficiency is the prime culprit. Staples such as rice, corn, pulses, and cassava are so poor in protein that a child cannot eat enough to supply his protein needs. Proteins of animal origin such as poultry meat and eggs provide a concentrated source of readily assimilable amino acids in suitable proportions for human needs. Vegetable proteins most frequently available in developing nations do not convert into body protein as readily as animal protein. Kwashiorkor due to inadequate protein is common in Africa, Asia, and Latin America, whereas obesity is a major problem in North America and Western Europe.

If food of adequate quality is to be provided in a sufficient amount to meet the needs of the world's expanding human population, animal nutritionists must work closely with veterinarians, geneticists, and other animal specialists to apply present knowledge to the problem. From the global standpoint, we have the knowledge and skill necessary to achieve easily an enormously increased output of animal proteins. A most important aspect of solving this problem lies in the long-term aim of education. Great numbers of young people must be trained in the basic techniques of animal production and given advanced training in the fields of nutrition and disease control. Many outmoded traditional husbandry systems persist.

Worldwide, the food picture is not good. It is said that half of the people are hungry; two-thirds suffer from malnutrition. World population is growing twice as fast as world production. Undeveloped countries have both the greatest population increases and the need for food. The United States is committed to help fight world hunger but the feed-food situation in the United States is at a turning point. The joker in the world food situation is the ability to pay. If standards of economy in some of the ill-fed countries could be raised, the problem would be easier to solve. If the peoples of Latin America, Asia, and Africa had income from some sources, the food would be available. There is no place in the world that

has a food shortage if the money is there to pay for it. Religious taboos, need for land reform, social customs, lack of incentive and a host of other government and sociological problems are involved. The American system should be exportable.

A meat-eating economy is based on an affluent society, an over-abundance of grain, a well-developed, sophisticated agriculture and strong purchasing power. Animal agriculture has certain limitations. Animals compete directly with man for his basic food supply, principally grains and high protein oil seeds. Animals are inefficient nutrient converters. More time and risk are involved in producing meat, milk, and eggs, and more skilled labor is required than for crop production.

Animal proteins have no magic exclusive nutritional values, just palatability. But the quality of the human diet is determined largely by the amounts of animal products consumed. Meat, milk, and eggs are especially important because they furnish high quality protein to balance the protein from vegetable sources. Many cereals and vegetables are too low in protein to meet the requirements of either adults or children and they are deficient in essential amino acids unless supplemented. Poultry meat is the richest source of protein per unit of energy, and eggs furnish liberal amounts of vitamin A, riboflavin, and iron. Many peoples of the world do not have supplies of these excellent foods because the conversion involves wastage of the total food supplies.

ED GLENNON, President
American Feed Manufacturers Association

Preface

From a source of the farmer's wife's pin money to a mass-produced, supermarket loss leader, poultry has made tremendous strides in the past half century. Paralleling its progress, and depending on it to a great extent, has been the feed manufacturing industry, two-thirds of whose volume is poultry feeds. It took a lot of doing, mainly by a team of scientists who ranged from nutritionists, geneticists, and biologists to pathologists, engineers and statisticians, to bring the U.S. poultry industry to its present efficiency. In the middle has been the poultryman trying to manage an enterprise that was growing nationally by leaps and bounds.

From expensive, New York-dressed, "chicken in the pot every Sunday," poultry has modernized to inexpensive, fully-dressed products that are marketed every day in the year, frozen or ready-to-eat. It has shown more progress than any other branch of animal agriculture.

In 1920, an average farm flock consisted of 200 hens or less; whereas today with advances in automation, the commercial poultryman may have 25,000 hens. Previous chores like mixing feed and housekeeping are done now by machinery so he can spend more time checking his chickens and trouble-shooting. Innovations in equipment and labor-saving devices developed by the poultry industry are being adopted by the livestock industry to a great extent.

Nevertheless, it takes more know-how and business acumen now to keep a poultry enterprise profitable. A poultryman must be more aware of other phases of the business. The more knowledgeable he is, the more likely he will survive in a very competitive business. Feed manufacturers must also be aware of the advances being made by poultry scientists so that their feeds measure up to the potential bred into modern birds. The amazing progress that has been made in recent years attests to the fact that communication between the groups is needed.

For many years there has been a need for greater application of the principles of nutrition to feeding practices as well as in preventing diseases of poultry. This treatise attempts to encompass the fields of poultry feeds and feeding in health and in disease in a concise and authoritative manner. It is hoped that it will help the nutritionist, veterinarian, and feeder to become more knowledgeable in the general area of poultry feeds and feeding and become a teaching aid for teachers and students of nutrition and feed technology, as well as for general poultrymen.

The solution of problems of nutritional improvement in poultry feeds

and feeding is vital to long-range betterment of standards for raising poultry and production of human food. Experienced feed formulators, feed manufacturers, county agents, vocational agricultural teachers recognize the necessity of using great care in the selection of feed ingredients for poultry. Nutrition principles explain the reasons why many established practices are very important in the formulation and mixing of feeds and provide the ways of assuring quality, uniformity, and the true value of manufactured feeds.

With nearly 80% of the world population needing an improved diet, any contribution toward producing more and better foodstuffs at lower cost is both worthwhile and timely. Feed and poultry production are not exact sciences but are based on knowledge, the base from which all progress is made. Critical phases of feed and poultry production, and current research are explored, and practical recommendations for meeting a variety of circumstances are made.

The U.S. Congress recently passed legislation authorizing the Bureau of Standards the possible adoption of the metric system. Half the world's population are now on the metric system. Canada and the United States are the only big countries still clinging to the fading imperial system. Britain hopes to have metrification completed by 1975. The simplicity and efficiency of the metric system is self-evident, its basis being the decimal point and the length of the meter. The latter is based on the wave-length of orange-red light given off by the element Krypton-86. The United States has had a legal metric system since 1866 which it does not use, while it uses the foot-pound system that has never been legalized. The benefits of a single measuring system are so great that conversion to the metric system is inevitable. Because of the international aspects of the book, measurements in the text are often given in both systems.

PHILIP J. SCHAIBLE

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CHAPTER 1

Introduction

Poultry nutrition deals with the laws governing the requirements of poultry for maintenance, growth, activity, and reproduction. Lavoisier in 1777 laid the foundation for the science of nutrition by supplying the basic facts regarding energy metabolism. Advances in physiology, and more especially the development of physiological chemistry in the last century, made possible efficient feeds and feeding. It is obvious that nutrition, feeds, and feeding are so closely interwoven as to be inseparable. Poultry assimilate feed for promoting growth, egg production, and replacing worn or injured tissues. Under the term *Nutrition*, the following are involved: digestion, absorption, metabolism, feed utilization, quantitative nutritive requirements, interrelationship of nutrients, etc. Under the subject of feeding are: composition and selection of feed, feed habits, feeds for all ages and conditions.

The Oxford English dictionary gave some ten different spellings of the word *diet* as it appeared in early English writings. It derives from the Latin *diaeta,* meaning mode of life. At first, it was used in the much broader sense than it is accepted today. It dealt with the doctrine of health and hygiene. This discussion will treat *diet* only as it relates to food and health.

For thousands of years, poultry ate anything that they could get. Not until the nineteenth century was it known that there was a difference in the dietetic value of different foods. *Ration* means a fixed allowance or allotment of feed in 24 hr or, more loosely, affixed portion or share of a feed. Roots, berries, fruits, and seeds were the first foods and later came honey, eggs, and fish of various kinds. It was not until the discovery of fire and cookery and the devising of weapons to kill animals that there was much use of animal foods. When man learned how to domesticate poultry, flesh and eggs became a part of his diet. He led a pastoral nomadic way of life with a necessity for frequent movement in search of new pastures. Man, the hunter, changed to man, the food gatherer. He learned to make tools so that he could crush seeds between stones to make meal and later, of course, flour for gruel, and then bread. By the time of Moses, fruits, seeds, herbs, bread, milk, fish, flesh, butter, honey, eggs, and cheese were man's diet and their waste products were used for feeding poultry. The early Egyptians, Greeks, and Romans cultivated food on farms, cooked their meat by boiling and roasting, and ate well. Storage or preservation of food was limited. Pickling, drying, salting, and smoking were early methods of

preservation. With the accidental discovery of the new world, Indian corn or maize added immeasurably to the food supply of man and poultry.

In sixteenth century Europe, meat and milk were still unusual foods but fresh, salted, and dried fish were common fare and vegetable growing was beginning to increase. By the seventeenth century, barley was in fairly general use. The invention of the steel-faced plow about 1840 led to the mass production of grain because the soil could be turned over to a depth sufficient to kill grass. The modern roller mill for breaking of the wheat grain and separation of bran, germ, and coarser grades of flour was developed about 1880. Since poultry was fed waste food from the human supply, their diets were more or less based on what was available.

The discovery of vitamins extends back through the years. Numerous observations indicated that some diseases could be prevented or cured by dietary changes. Although advanced knowledge in chemistry and analytic methods helped, it still required the development of a biologic technique using chickens, rats, guinea pigs, dogs, and other experimental animals to chart the way to identification of the essential food nutrients. There was considerable reluctance in the acceptance of dietary deficiencies as the explanation of disease because the work of Pasteur had finally been accepted and the infectious origin of disease was the dominant consideration.

A natural subsequent development in the matter of what foods poultry should eat, was the question "how much?" Quantitative studies advanced only with progress in chemistry, and thus little could be done in this area until the nineteenth century.

In simplest terms, poultry nutrition is concerned with what poultry need to eat in quantitative amounts of specific nutrients. This, of course, involves the "why" of the subject. Feeding is concerned with what poultry *do* eat in order to meet their specific needs and what they *should* eat in terms of individual variation, state of health, activity, and all the factors which influence selection of rations.

Markets for the Poultry and Feed Industries

Feed is needed to produce poultry, a substantial part of the food industry. The size of the food industry depends on population which is not constant. A tripling of the world's food supply will be necessary in the next 30 yr if 7 billion people in the year 2000 are to be adequately fed. The U.S. Dept. of Agr. estimates that the United States cannot continue to feed developing countries after 1984. If today's trends continue, there is likely to be further rapid deterioration in man's environment.

A fantastic world effort over the next decade at changing the attitude of people toward family size might conceivably arrest population at 2 or 3 times its present level. Some biologists feel that compulsory family regulation will be necessary to limit population. World population is exploding. More children are being born, many diseases have been cured, and the lifespan is increasing. It took from the beginning of time for world population to reach 3.3 billion; by 2000 A.D. that figure will more than double (Table 2.1).

TABLE 2.1

POPULATION PROJECTIONS: WORLD AND MAJOR AREAS—1965 AND 2000

World and Major Areas	1965	Population in Millions in Year 2000 on the Basis of Trends		
		Present	Medium	Low
World	3308	7410	5965	5296
Asia	1842	4401	3307	2969
East Asia	867	1803	1284	1114
South Asia	965	2598	2023	1855
Africa	311	860	768	684
Latin America	248	756	624	514
Europe	443	571	527	491
Northern America	215	388	354	294
Oceania	17	33	32	27
U.S.S.R.	234	402	353	316

Source: Population Reference Bureau, Washington.

The answer to the problem of feeding tomorrow's world is found in its agriculture and the men who grow food—farmers, feed manufacturers, livestockmen, and poultrymen. In the United States 1 farmer produces food for 40 people and thus frees the others to work at jobs on which the nation's progress depends. But agribusiness is more than one farmer feeding so many people. It is processors and distributors who make the food

available to the people. It is science providing new seeds, livestock strains, pest control, technical knowledge, and modern methods. It is educators teaching the young in the ways of agriculture. It is companies that make the hundreds of items farmers need. Food production has its roots deep in the farm.

Americans eat on the average 1,500 lb of food per year. The amount needed to feed Americans in 2000 A.D. is 135 million tons of food a year more than is being produced now.

Industries playing increasing roles in the struggle against world hunger include the poultry industry which requires less capital to enter than other animal industries, and the feed industry which provides economical feeds upon which the poultry industry depends. More than 96% of all food originates on land rather than from the seas.

FOOD CHAIN

Solar radiation energy is the driving force that keeps the earth's system going. Energy is captured by the food producers which may be simple algae in the water and rooted plants along the shore. All animals are predators either on other animals, plants, or both. Passage of materials from producer through primary, secondary, tertiary, quaternary, etc., consumers is called a "food chain." The end is generally an organism that is not preyed on by any larger form.

Each step along the food chain extracts only a fraction of the potential energy of the previous step. The food chain, thus involves a series of energy conversions; with each transformation from prey to predator along the food chain there is a loss of energy.

All organisms live in nature in a close and delicately controlled relationship with a great many other organisms forming a biotic community. It is said that the glory of England was due to its old maids. It is reasoned: "British men are nourished by roast beef; the cattle that supply the roast beef feed on clover; clover is pollinated by bumble bees; bumble bees nests are destroyed by field mice; and the number of field mice depends on the number of cats. Since old maids keep cats, their number ultimately determines how much roast beef is available." As far-fetched as this argument is, it nevertheless, emphasizes the important principle that in any biotic community the existence of each species, as well as each individual, is governed to some extent by the presence of all the others. Organisms depend on each other, directly or indirectly for day-to-day existence, but also compete for the resources available in the environment. This competition is mainly for energy to maintain itself and reproduce. A population of organisms with an unlimited food supply could quickly fill the entire earth with their own kind. The food supply of any population of organisms is