COMMERCIAL BROILER PRODUCTION

Agriculture Handbook No. 320

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

GOOD MANAGEMENT PRACTICES IN RAISING MEAT BIRDS

(1) Start with quality chicks; get healthy chicks from National Plan hatcheries or other reliable sources.

(2) Have chicks of only one age on farm at any time.

(3) Debeak chicks when necessary.

(4) Clean quarters before housing birds and keep houses and equipment clean.

(5) Keep litter clean, dry, and free from mold.

(6) Brood birds carefully; have good sanitary management in brooder house.

(7) Supply adequate heat and ventilation.

(8) Provide enough floor space.

(9) Give adequate space for feed and water; have feed delivery to bin outside house.

(10) Use all-night lights.

(11) Adapt vaccination schedule to local needs.

(12) Watch for disease; get prompt diagnosis when disease occurs; remove diseased birds from flock.

(13) Dispose of dead birds promptly; have satisfactory disposal facilities.

(14) Keep visitors out of houses; lock doors.

Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not signify that the product is approved to the exclusion of other comparable products.

COMMERCIAL BROILER PRODUCTION

By ***RAYMOND T. PARKHURST***

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D.C. **Issued February 1967**

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 40 cents

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This handbook supersedes Agriculture Handbook 151, Broiler Feeding.

CAUTION

Feed Additives—When a medicated feed is used, follow the manufacturer's directions exactly. Directions on the label or feed tag are based on U.S. Food and Drug Administration regulations governing the use of a medicated feed, its withdrawal, and replacement with a nonmedicated feed. (See reference in footnote 1, p. 40.)

Poisons for Controlling Rats and Mice—All poisons are dangerous and can kill small animals and pets if used carelessly. Anticoagulant rat poisons—warfarin, pival, fumarin, and Diphacinone—are safe when used according to the manufacturer's instructions. They may be purchased as powdered concentrates for dry baits or in water-soluble form. Follow all directions and heed all precautions on the label.

Insecticides—Insecticides are poisonous; use them with care. Follow all directions and heed all precautions on container labels. Do not contaminate feed and water with insecticides.

COMMERCIAL BROILER PRODUCTION

By Raymond T. Parkhurst, *Director, South Central Poultry Research Laboratory, Agricultural Research Service*

Commercial broiler production is a highly specialized farm enterprise. In 1952, the annual production of commercial broilers exceeded that of farm chickens, including hens that were by-products of egg production. The total output has increased from 34 million broilers in 1934 to over 2,300 million in 1965. Except for small decreases in 1944 and 1946, the annual output of broilers has increased each year since 1934. The average price per pound paid to the producer and the value of broiler production have fluctuated. Prices have tended to decline, and the total value of production has inclined to over $1 billion in 1964.

Commercial broilers are produced at a relatively uniform rate the year around. More are raised to meet the greater demand in the summer because of more outdoor cooking and fewer during the winter holidays when more turkey is on the market. The per capita consumption of broiler meat has increased rapidly since 1947–48, as shown in figure 1.

The large-scale production of broilers has developed in concentrated areas. The first such area was probably the Delmarva Peninsula, which includes all of Delaware and parts of Maryland and Virginia on the Eastern Shore of Chesapeake Bay. Virginia also has several sizable producing areas. Georgia has recently been the largest producing State. Other concentrated areas of output are in Arkansas, Alabama, North Carolina, Mississippi, Texas, Maine, and California. The southeastern and south-central regions have had the greatest increases in recent years, as shown in figure 2.

CURRENT TRENDS IN BROILER RAISING

Production Centers

The center of broiler production has moved in recent years from the eastern seaboard—the Delmarva Peninsula, Maine, and Connecticut—to the Southeastern States of Georgia and North Carolina and the South Central States of Arkansas, Alabama, Mississippi, and Texas. In 1964, the 10 leading States in broiler production produced 1,800 million birds, or 84 percent of all the broilers in the Nation. Area competition is primarily dependent on production and transportation costs of processed broilers.

Growth of the Broiler Industry

For several years and especially from 1955 to 1962, the cost of producing and marketing broilers has had a downward trend. Although prices have also been less nearly every year, producers have offered increasing supplies. The cost reduction has been due to many factors. Advances have been made in nutrition, breeding, management, and in the prevention and control of diseases. The improvement in feed efficiency has been the most important factor in reducing the total cost per pound of the broiler. Radical changes have been made in the way the broiler enterprise has been financed and organized. Live birds have been more accessible to processing plants. The availability of high-quality birds in a convenient form and at reasonable prices for the consumer has enhanced the demand. Population and take-home pay have increased. The volume of output has become more constant throughout the year.

Competition has been intense in the broiler industry, forcing many firms and their producers out of business. Firms with more profitable margins have usually taken up the slack caused by the closing of less efficient firms. Lack of availability of credit has at times slowed the expansion rate. On the other hand, the trend has been for more broilers to be raised per farm. Broiler raisers have increased the size of their houses and have installed labor-saving equipment to care for more birds. Labor cost per bird has been lowered.

Commercial broiler production may be a full-time enterprise, part-time with some industrial pursuit, or combined with farming operations, such as the production of corn, cotton, soybeans, hay, or beef cattle. Many broiler growers do not depend entirely on the income from their chickens.

The ability of the grower can be an important factor in the growth of an individual enterprise.

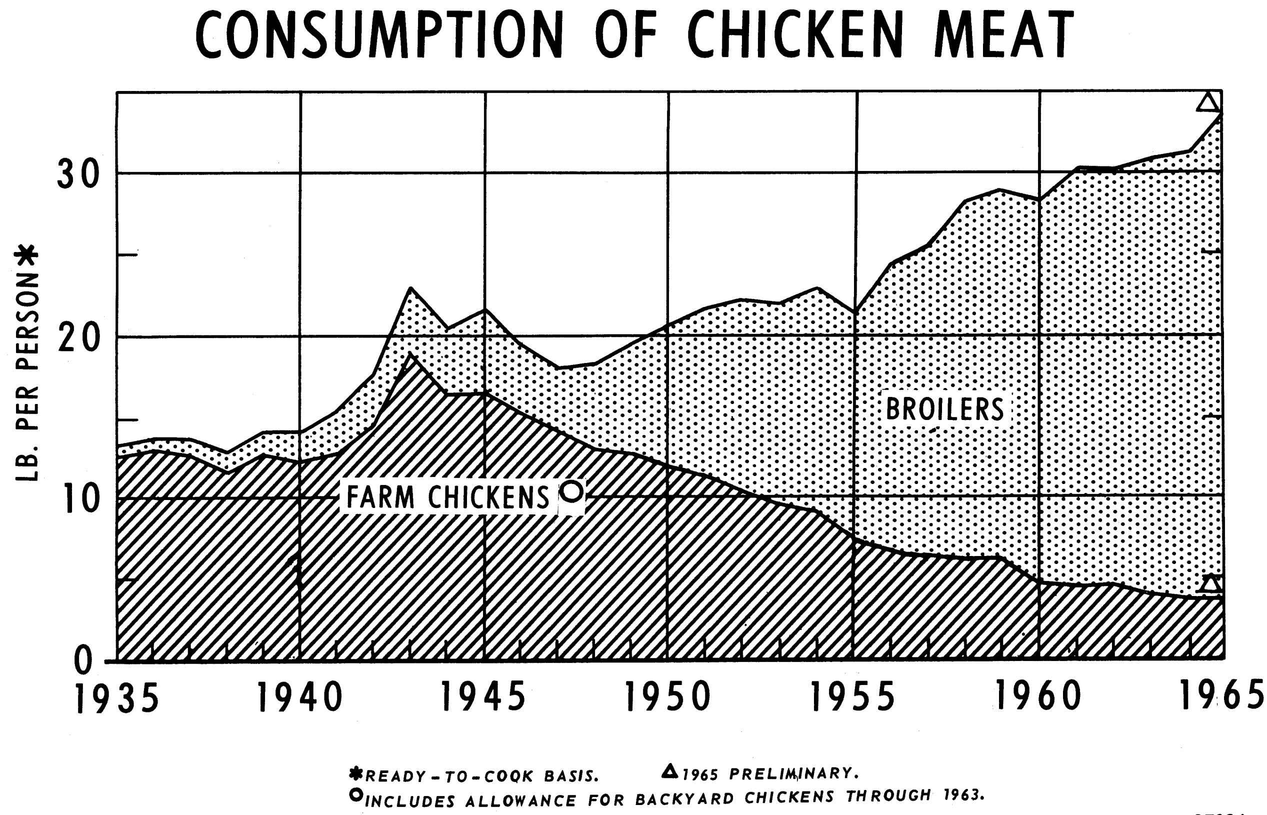

FIGURE 1.—Consumption of commercial broilers and farm chickens, 1935–65. Note rapid and almost complete replacement of farm chickens by broilers.

His decisions as to heat, ventilation, feeding, disease control, and similar matters, even under the supervision of service personnel, can materially affect results.

The competition for labor can be a very important factor in the growth of broiler production in an area. If broiler growers have no alternative, they will probably continue to operate when prices are depressed and income is low. However, when industries offer an alternative revenue, the wage offered, the relative "pleasantness" of the jobs, the time of year, the duration of the job, and the skill and responsibility required all become factors. In the South, historically, there have been fewer agricultural alternatives and less industrial demand for labor.

Integration

Poultry-meat production has passed through several stages of development. Originally meat production was a byproduct of egg production, and much of the poultry meat was from milk-fattened roasters from the Middle West and the South Shore of Massachusetts. There was some specialization of production close to the eastern markets, where premium prices were paid for small broilers and "South Shore" roasters. Most of the early commercial broiler production was by independent growers. They paid cash for everything and took all the profit. As margins became smaller, flocks became larger, and soon the feed dealer became the source of credit. As the industry grew, the feed dealers began to depend on the feed manufacturers as a source of funds. To spread their risk, both feed dealers and feed manufacturers integrated vertically with hatcheries and processors. This was the start of many forms of integration.

Integration may include one or more phases, such as financing, feed, hatching, breeder stock, production, processing, and retail marketing. In most cases, the primary production of breeding stock and retailing have not been included. Many companies may be involved in a single operation, such as processing, or a single corporation may encompass all the phases. Some corporations are publicly financed, and their operations often include most of the phases enumerated above.

Several forms of integration apply to broiler production. Horizontal integration is the combining of firms in the same stage of production. It may result in better control of production and increased efficiency. For example, many feed

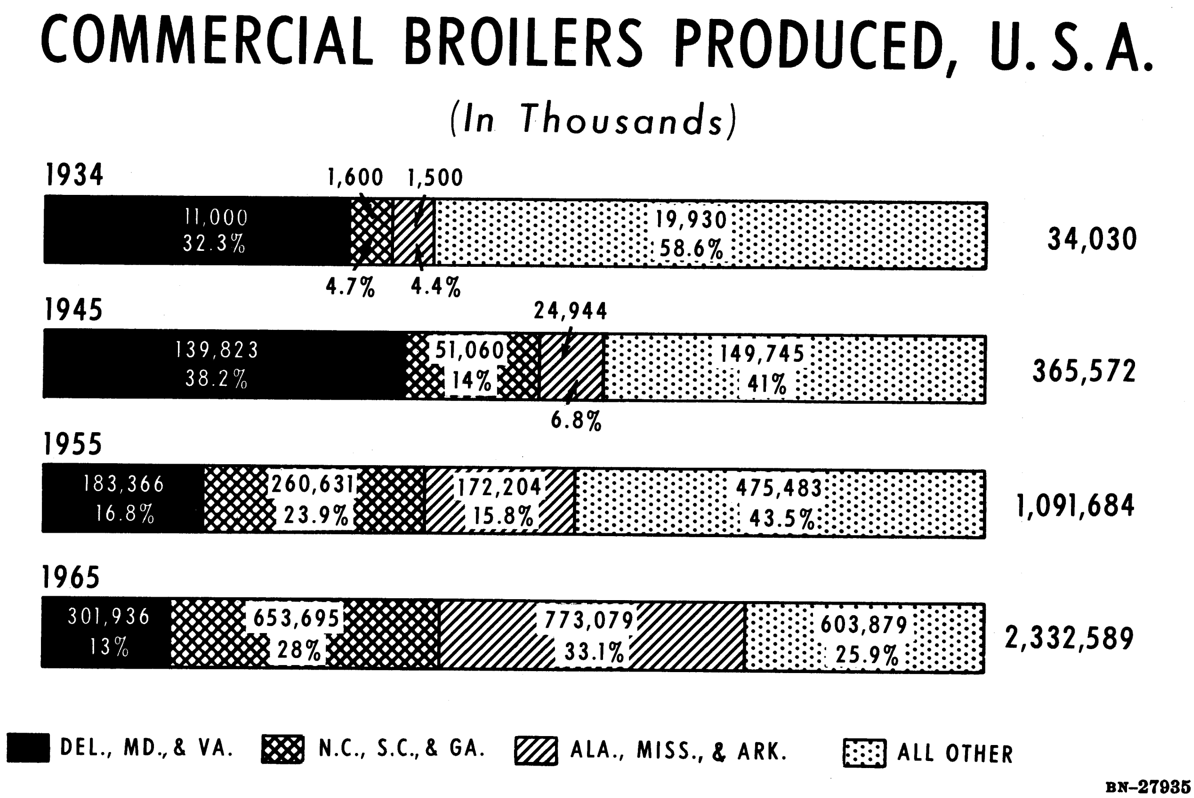

FIGURE 2.—Commercial broilers produced in selected areas, 1934–65.

companies have merged. Vertical integration is the control by a single management of two or more stages of production. It is said to be backward when it undertakes to maintain access to materials. For example, processors may wish to assure a supply of birds in order to get as near full capacity as possible. They may contract with growers when supplies are limited. Forward integration usually has the maintenance of the market position as its purpose. Feed manufacturers have integrated to try to hold their volume. They are strong factors in production and, in some cases, include all phases of integration except retailing.

Ownership integration is one brought about by merger or by expansion of a firm. Contract integration coordinates nominally independent enterprises by a system of contracts. Probably 95 percent of the broilers are grown under some type of vertical integration or contractual arrangement. This is due primarily to capital and credit requirements, reduced unit costs, improved quality, better alinement of output with other stages, especially processing, and reduced operation uncertainties as to capital inputs and market outlets. Because of the larger volume base, better management and service, more research, and easier maneuverability of sales are possible. An integrated business can be more effective if it is more efficient.

Financing

The methods of financing the poultry industry undoubtedly contribute to its principal problem—low prices and marginal returns.

Few growers are still able to continue as independent operators. Throughout the broiler industry the amount of integration has increased. One of the principal reasons for this trend has been the increasing need for more financing. Because operators tend to be more responsible financially, more liberal credit has been extended to integrated operations or to those persons who have, in their normal business activities, used considerable credit. Feed manufacturers are an example of this group.

Local banks, their correspondent city banks, and the Production Credit Association largely finance the broiler industry through credit extended to feed manufacturers, dressing-plant processors, hatcherymen, and integrated operations. Much of this money is loaned at the local level to growers with mortgages as collateral. Some of the larger cooperatives get their money through the Bank of Cooperatives, especially for processing and other marketing purposes. Much of the money for broiler-house construction has come through the Federal Land Bank Association, the Production Credit Association, and individuals. The loans are usually payable over a 5- to 20-year period and are secured by mortgages. The Farmers Home Administration makes loans for the development and operation of broiler production on farms no larger than family farms. Established broiler producers may obtain credit to continue or to make needed adjustments in their broiler operations. FHA, however, only finances the establishment of broiler enterprises on a limited scale. Insurance companies also make mortgage loans in some areas.

One of the reasons for the rapid expansion of the poultry industry in the South has been that financing is easier there. A dollar goes farther, especially in poultry-house construction. More capital has been available to invest in poultry enterprises there.

Contracts

Good contracts state terms concisely and divide fairly the responsibilities of the grower and management, or the company with whom he has a contract. Most broiler growers are concerned with two major risks, which generally make them either unable or unwilling to finance their own broiler operations. The first is the risk of unusually high mortality and the second is that of unusually low market prices or sometimes a lack of a satisfactory market for their birds.

In most contracts the firm supplies the baby chicks, retains ownership of the broilers, assumes responsibility for marketing the birds, and promptly pays the grower. The firm also supplies feed, supervision, medicine, vaccines, and disinfectants. It assumes most cash losses. The grower supplies labor, housing, equipment, fuel, litter, and miscellaneous items.

The out-of-pocket purchases of the grower are usually low. However, his costs should be taken into consideration. They include repairs, depreciation, taxes, interest, and insurance. Repairs are a part of the cost of trying to stay in business. The grower must get back the cost of depreciation or he is out of business when his houses and equipment are beyond repair. The grower is usually taxed on everything he owns, including land, houses, and equipment. Insurance is a justifiable protection against losses that might wipe him out. He is responsible for personal injuries. The grower gets the manure produced.

There are many kinds of production contracts. Most contracts guarantee the grower at least something for the use of his houses and equipment and for electricity, water, and minor cash outlays. When prices are depressed, growers may receive little or no return for their labor. In general, growers with inadequate housing and equipment, poorer-than-average feed conversions, high mortality, or poor condemnation records find it increasingly difficult to get contracts when weather is adverse, output is curtailed, or broiler prices are depressed. In recent years, this has been around Thanksgiving and Christmas. To obtain maximum returns, producers need to make full and continuous use of their facilities and labor. Contractual arrangements are very important.

Production operations are financed in many ways, such as open account, no loss, share, flat fee, labor, and feed conversion. With the open-account plan, the grower buys his feed, chicks, medicine, vaccines, and other supplies from the dealer, who takes a chattel mortgage on the birds. The dealer supervises the operation, does the selling, collects payments, and credits the grower's account. The dealer does not assume the production or price risks.

The guaranteed no-loss plan is similar to the open-account plan except that should the income be less than the credits extended, the dealer absorbs the loss and closes the account. The grower loses his labor and the returns on the use of his house and equipment. He, of course, directly or indirectly, pays for the guarantee against loss.

The share contract was used extensively in the eastern broiler-growing areas. The feed dealer usually furnished the feed, chicks, medicine, fuel, litter, and other production items, charging them to the grower's account. The grower furnished the broiler house, equipment, and labor necessary to grow the birds to marketable age. The dealer retained title to the birds and made the decision on marketing. After deducting the charges for feed, chicks, and other supplies from the net proceeds from the broilers sold, the dealer retained a share of the remaining proceeds and remitted the rest to the grower. The share varied from 90–10 (90 percent to the grower and 10 percent to the dealer) to 50–50. If the proceeds were less than the charges, the dealer stood the loss, except for his markup. The grower received no return for his labor or for the use of his buildings and equipment. Other types of contracts replaced the share contract because of the unwillingness of growers to take the risks involved and because of the growth of the efficiency-type contracts.

Another share-type contract was used extensively during the period when broiler prices were depressed and integration was spreading. In this contract, feed was charged at ingredient cost, and the hatchery received a minimum agreed price for its chicks. The grower, hatchery, and feed mill divided the profits 38, 25, and 37 percent, respectively. Operators of the feed mill and hatchery assumed losses at 60 and 40 percent, respectively. The grower, in case of a loss, received nothing for that lot of broilers. However, he usually received more per 1,000 broilers when the selling price was relatively favorable than under a guaranteed no-loss or the share-the-profit contract.

Under the flat-fee contract, the dealer furnishes the chicks, feed, medicine, vaccines, and other production items and does the selling. The producer furnishes the house, equipment, and labor. The dealer retains title to the birds and pays the grower a guaranteed minimum per chick placed per week or per pound of broiler marketed. The latter is generally considered preferable because of a direct reward for low mortality.

Another form of this contract provides that the minimum payment drops when the price per pound of broiler sold drops below a certain price. For example, the contract payment may drop from 2 to 1½ cents per pound of broiler sold when the price per pound of broiler sold goes below 15 cents per pound.

The labor contract is similar to the flat-fee contract, except that the grower is paid a fixed wage by the dealer, usually on a weekly basis. The plan may be used when houses are leased.

There are several types of "efficiency" contracts, and the trend is toward their use. Basically the grower gets a percentage of what he saves the management. This type of contract provides the grower with an incentive to practice good management. The management retains title to the broilers, supplies all production items, supervises production, markets the broilers, and assumes the loss responsibility. The grower furnishes houses, equipment, fuel, electricity, and water.

One contract pays a fixed price per pound of broiler sold with an increase or a decrease in the base rate depending on the feed conversion of each batch. For example, the grower may have a guarantee of a cent per pound. Market price is not a factor. The grower is paid 0.1 cent per pound for each 0.1 pound below 2.5-pound feed conversion and the same, 0.1 cent per pound, for each 0.1 pound above a 3.0-pound average weight and for each 0.5-percent mortality below 4-percent mortality.

Modifications are based on "point spread" or the "production efficiency" index. The point spread, described in detail on page 29, is the relationship between the feed-conversion ratio and the live weight of the birds at the time of marketing. An average weight of 3.33 pounds and a feed conversion of 2.50 gives an 83-point spread. These relationships may also be expressed as the production efficiency index by dividing the live weight by the feed-conversion ratio. For example, the index for the weight and conversion above would be 1.33 ($3.33 \div 2.50$).

Another contract pays an agreed amount per 1,000 chickens started. A payment is made on a feed-conversion factor, a differential according to the selling price, or both; point spread; or cost of production. No perfect contract has been devised to take care of all conditions. Some of the variations in the contracts concern fuel cost, distribution of profits, floor space allowed per chick started, allowance for putting insulation or central heating in the houses, penalties for condemnation losses, extra allowance for cost of fuel during colder-than-average periods, cost of disinfectants and of applying them, cost of litter, cost of cleaning out houses, and cost of catching and hauling birds to market.

In most broiler areas, the condemnation losses are charged to the growers. Some operators give a fuel allowance to the grower when the weather is more severe than usual. This tends to increase feed conversion and reduce mortality and condemnation losses. Growers who have or put in insulation in an approved way are usually given an allowance to help reimburse them for it, if they are not paying the fuel bill.

Contracts vary with different dealers and integrators. They may combine features of various types. Company-owned broiler farms result primarily when it is not possible to get growers with either adequate houses or managerial ability. Managers of company-owned farms often are supplied a house, are assured a minimum income, and then are paid a bonus for doing a better-than-average job. Farms may be owned or leased by the company. There are several reasons for control by either ownership or leasing. The principal one is that contractors have the responsibility for production, but insufficient authority over producers to match their responsibility. Some of the advantages of expansion by leasing over ownership as far as integrators are concerned are the lowered fixed costs that are direct business expense, conservation of capital, better utilization of labor between farm and nonfarm work, and tax advantages. In some cases, the grower, in addition to leasing his houses, also works for the integrator or contractor on a fixed salary or labor contract.

Cost-of-production contracts are being used to reward those growers who get good feed efficiency and use enough, but not too much, fuel and medication. The many different types of these contracts include a guarantee payment per 1,000 birds and a payment of an added bonus per pound to the grower for profit over the break-even point and a reduction of the same amount for a loss below the break-even point. Another type predicts an average cost for the period during which the birds are to be sold, and payments to the grower vary above or below the average. The grower and the contractor split the profits, if any, above basic production costs and payments made to the grower. In another type, the contractor averages the cost during the week, month, or quarter for all growers and pays a bonus to the best growers. Less efficient growers get something, but usually have difficulty renewing their contracts.

By its survival, contracting in one form or another has demonstrated that it is a more satisfactory system than any alternative that has been mutually acceptable to participating parties. Contracting is firmly established in the broiler industry. Most broiler growers will not finance their operations independently even when they can. The extent to which the grower under the contracting system loses his independence to a considerable extent depends on his attitude and that of his family. Servicemen, representing management on the farm, welcome the opportunity to turn over responsibility to the grower. When the grower and his family prove themselves capable of making the day-to-day decisions, they will usually have the opportunity to do so. In contract farming they have a new variation of the traditional system of family farming.

The type of contract that exists between the hatchery and the producer of hatching eggs has an important bearing on the wide fluctuation in broiler prices. The industry could adopt a policy of compensating the producer during those periods when it is necessary and advisable to reduce or stop setting eggs. An average-volume guarantee is sometimes used to assure hatching eggs when wanted, yet cut off supplies when not needed.

COST OF PRODUCTION

General Guide

The cost of producing broilers varies with every batch. As a guide, the percentage of each item, other than grower payments (labor and overhead), to be considered in the cost of producing broilers is approximately as follows:

Item	*Percent*
Feed	71.00
Chicks	21.80
Fuel	2.25
Medication	1.8
Vaccination	1.35
Litter	.9
Miscellaneous	.9

When contract payments are included in the costs, the percentages are approximately as follows:

Item	*Percent*
Feed	62.4
Chicks	19.2
Grower payments	12.0
Fuel	2.0
Medication	1.6
Vaccination	1.2
Litter	.8
Miscellaneous	.8

Feed is the largest cost item. Feed and chick costs represent 80 to 90 percent of the total cost. For information on cost of labor and on economical feeding, including cost of production and how to calculate it, see pages 7 and 29–32.

Some variation in grower costs, even within a single enterprise, is due to different ways of doing the same job. When the result is a difference in weights, feed conversion, or mortality, the cost is materially affected. It is often possible for an individual broiler grower to improve his efficiency. For information on labor efficiency, see page 7.

The usual objective is to lower production costs to give greater profits. Production costs generally are lowered if one combines all the improvement possible in the breeding of the broiler stocks used, nutrition and feeding, prevention and control of disease, and management, including environmental control. This requires close cooperation between the operator, the service supervisor, and the grower. If there is friction or a lack of confidence between the supervisor and the grower, optimum results rarely are obtained.

Baby Chick Cost

The cost of baby chicks has been reduced because of improved hatchability. Most of the reduction has been due to the decreasing costs in hatching as hatchery size increased and fuller use has been made of facilities. The trend, especially since 1955, has been to fewer but larger hatcheries. The total production has increased enormously. The relatively stable year-round demand for broiler chicks has resulted in greater use of facilities. With integration, a much better balance has existed between hatchery capacity and the needs of production and marketing. As hatchery size increased, reductions resulted on a per chick basis in in-plant labor, cost of utilities, and overall cost of the hatchery building. The labor costs were substantially reduced. The inefficiently operated hatchery will probably not survive when its cost of producing chicks is too high.

The major factors in baby chick expense are egg cost and hatchability. A 10-cent difference in the cost of a dozen hatching eggs will change the chick cost about 1 and 1.25 cents at 84- and 70-percent hatchability, respectively. At 50 cents per dozen eggs, a drop from 84 to 70 percent in hatchability will increase the chick cost 1 cent. At 70 cents per dozen, the cost per chick goes up about 1.33 cents. In integrated operations especially, these factors become very important.

Grower Payment Costs

It is estimated that about 12 percent of the total cost of producing a broiler is the payment to the grower for his labor, the use of his house and equipment, electricity, water, and minor cash purchases. In an efficient operation, about 5 to 6 percent will be housing and equipment charges and 6 to 7 percent will be labor.

Labor Cost

In general, the better the housing and equipment, the lower the labor cost. The labor per 1,000 broilers started should not exceed 31 minutes per day, and with automatic equipment, should not exceed 18 minutes per day. The hours per 1,000 per brood should not exceed 17 without, or 9 with, automatic equipment. This is based on a 66-day growing period and, of course, would vary for different length periods.

A family unit on a full-time basis should care for at least 36,000 broilers, preferably 45,000. It would be necessary to have mechanical feeders and waterers. Eight hours would be required daily during the brooding period—feeding and watering approximately 3 hours each, brooding ½ hour, and flock inspection, regulating ventilation, management of litter, and other miscellaneous chores 1½ hours. After the brooding period, about 6½ hours daily would be required—feeding 4, watering 1, and miscellaneous tasks 1½ hours. If mechanical feeders were not used and round hanging feeders were utilized, almost twice as long would be required to feed 36,000 broilers, and some hired help probably would be needed. Usually hired help would be required only to clean out and to repair houses and equipment.

Contract farming is normally a family affair. The wife and children help, especially during the first 2 weeks. The trend is to large-scale, full-time operations and away from part-time production. When there is surplus labor, labor-saving equipment must be considered only in terms of reducing fatigue and drudgery in certain jobs and not of reducing cost of production. A grower can calculate his labor income fairly accurately if he knows his ownership costs and subtracts his fixed costs from his minimum contract guarantee.

Grower Fixed or Housing Costs

The amount of fixed costs per unit (square foot or broiler) will depend on the amount of money invested in land, buildings, and equipment; the assumed rate of depreciation; and the expenditures for taxes, interest due on borrowed capital, repairs, and insurance on buildings and equipment. The only other direct costs are probably hired labor and cash outlays for electricity, water, and possibly land rental.

Depreciation on buildings is usually figured at 5 percent, or 20 years, and on equipment at 10 percent, or 10 years. Interest is charged at 6 percent for buildings and equipment at the level of investment. Repairs amount to 1½ percent on buildings and 2 percent on equipment. Taxes on land and building and insurance on buildings and equipment are charged at three-fourths percent of the level of investment. The level of investment will depend on the age of the buildings or equipment. When not known, it is assumed to be one-half percent. For example, annual interest is figured at 3 percent for buildings and equipment and is equivalent to 6 percent on total investment.

Assuming investment cost in the house of $1 per square foot, the cost per broiler capacity at 0.8 square foot allotted per bird is 80 cents. The annual fixed costs in cents per square foot, based on $1 per square foot, are as follows:

Item	*Cents per square foot*
Depreciation	5.00
Interest	3.00
Repairs	1.50
Taxes	.75
Insurance	.75
Total	11.00

(For housing and equipment costs, see p. 16; of course, these costs may be half or double the amount indicated here.) Assuming 25 cents per square foot for equipment, including automatic feeders and waterers, the annual fixed costs in cents per square foot are as follows:

Item	*Cents per square foot*
Depreciation	2.50
Interest	.75
Repairs	.50
Insurance	.25
Total	4.00

When the total annual fixed cost for housing and equipment is 15 cents per square foot, the annual fixed cost per 1,000 broilers at 0.8-square foot density is $120 (0.8×0.15×1,000). With four flocks per year, the cost is $30 per 1,000-bird flock, or 3 cents per bird. At 3.3 pounds per broiler, the total fixed cost per pound is 0.91 cent (3.0÷3.3).

If a grower has a fixed cost of 0.91 cent per pound and is paid 2 cents per pound as a minimum base, his return for labor is 1.09 cents per pound. At 3.3 pounds, the labor return is 3.6 cents (1.09×3.3) per broiler. For four flocks per year, the basic labor income would be $144 per 1,000 ((4×3.6×1,000)÷100). The amount of labor income a grower receives is affected by the fixed costs per unit (pound or broiler), what he is guaranteed per unit in his contract, how many units he produces (flocks×broilers per flock), and what he has in his contract as bonuses or discounts based on performance, selling price, or both.

In the example given here, the grower payment should be at least $66 per 1,000 broilers ((120+144)÷4). However, minimum grower payments may vary from $50 to $75 per 1,000 started or from 1 to 2.25 cents per pound of live broilers marketed. Contract payments vary considerably, but are usually about 1.7 to 2 cents per pound.

Depreciation can vary with the quality of the house and equipment. Some houses are built to last 20 and others 10 years. If of poor quality or not given proper care, they will last only 5 years. The interest charges vary with the risk involved and the various sections of the country. The personal property tax varies a great deal because of differences in assessed valuation and local tax levy. Some of the factors affecting repair and insurance expenditures that the grower will make on buildings and equipment are his anticipated earning power (his age), especially how near he is to retirement, and the amount of mortgage, if any. With a diminishing level of income, the expenditures for these items are reduced or postponed. New buildings and equipment will require less maintenance. Miscellaneous expenses include cost of electricity and water supply.

Some of the most important factors affecting grower costs are the number of flocks per year, the time between batches, and the type of housing and equipment used. Fixed costs become higher per broiler when only two or three batches are raised in a year or the houses are not filled to capacity. The time between batches will depend, in addition to other factors, on the number of times per year the house is cleaned out and the method used. Inefficient methods of cleaning between batches can markedly increase the cost of production. The broiler house should be designed for easy cleaning (see p. 13).

Litter Cost

The cleaning out of the house can vary in cost. The value of the litter must be determined on an individual project basis. When the broiler project is part of a farming enterprise, the litter can be valuable. In some cases, old litter is given to whoever will clean out the house and refill it with clean litter. Sometimes nobody wants it. The cost of removal also varies depending on the method used, such as shoveling by hand into a wheelbarrow or wagon or scoop loading into a manure spreader. For further information, see page 20.

SELECTION OF STOCK

Straight-Run Versus Sexed Chicks

Straight-run chicks are generally used for raising broilers. Growth rate and feed conversion do not seem to be materially different if the sexes run together or separately. Cockerels grow more rapidly and convert their feed more efficiently than pullets and are more profitable to raise. Being heavier at a given age, there is more weight over which to spread chick and contract fixed costs. Very little convincing data are available that the advantages of separating the sexes, if any, offset the costs involved. Since the demand has been for only white-feathered broilers, there has been very little interest in sex-linked crosses, which facilitate separating the sexes at hatching time.

Breeding Methods

The science of genetics has been and is being continuously utilized to improve broiler breeding stock. Hybrid vigor is obtained by systematic matings that may involve crossing of different breeds, different strains of the same breed, or the crossing of inbred lines. In addition to hybrid vigor, improvement in economic factors often results from these crosses, provided the mating includes stocks having superior qualities of genetic origin.

The end product—our modern white, yellow-shanked broiler—is often obtained by crossing the male lines from specialized breeders with female lines produced likewise by specialists. Each line may be the result of crossing two or more strains. The male lines usually have dominant white feathers and are selected for rapid growth; meat characteristics, such as breast width, body depth, live market grade, and dressing yield; and rapid feathering. The female line also must have outstanding growth rate, high hatchability, and good, but not outstanding, production of eggs of desirable size and texture. Considerable attention has been given recently to additional factors, such as freedom from *Mycoplasma gallisepticum*, feed efficiency, skin texture, skin and shank pigmentation, and, in the case of large broilers, roasters, and capons, feathering on the breast or absence of breast blisters.

If male and female lines are produced by different breeders, as they often are, each line must, to remain competitive, cross well with other lines. Progeny test and family selection have been effective in the development of broiler lines. The buyer must judge the ability of male and female lines to cross well, whether the lines are developed by separate breeders or the same breeder.

The selection of a commercial broiler stock can be the determining factor between profit and loss. Extension poultry specialists and county agricultural agents can provide information that will be helpful in making the selection. The results obtained by other growers in the area from different stocks on such factors as growth, feed conversion, viability, and rate of condemnation should be considered.

In large broiler operations, a common practice is to test several stocks on one farm where suitable facilities are available and careful records are kept. It is important that the housing, feeding, and management be uniform for all stocks in order to obtain a valid comparison of the factors affecting economic returns—rate of growth, pounds of chicken per 100 pounds of feed, mortality, and quality of broilers produced. The information will provide a more reliable basis for the selection of a stock if the tests are repeated on a second or third farm. The farm or farms selected for the test should follow production practices typical of the area.

In intergrated operations, the comparisons may include such factors as egg production, fertility, and hatchability of the parent stock. Other considerations are the cost and availability of the stock and the services provided by the supplier.

Growth and Feed Efficiency

Growth (final broiler weight) behaves genetically as a simple quantitative character. The demand of the processor for a white bird created a problem for the geneticist, because the dominant white gene seemed to be linked with some growth-depressing factor.

There seems to be no advantage in using any linear measurement over body weight alone. Growth (9-week weight) has been positively correlated with other important economic factors, such as breast width, body depth, and fleshing.

The relationship of egg production to broiler weight at 9 weeks is important. If it is desired to improve egg production in otherwise desirable meat-type breeding stock, it seems advisable to make intense selection for growth rate in stock that is slightly inferior in growth but much superior in egg production. The more rapidly growing birds are more efficient than the slower growing birds.

It is known that feed efficiency is inherited. There is some question whether it is practical for the commercial broiler breeder to select for it as a specific factor. It would seem more practical to assume that selection for rapid rate of growth at 4 to 6 weeks of age, and possibly including long shanks, is also selection for high feed efficiency. Sex-linked genes may be of considerable importance in the expression of both growth and feed conversion. Since birds selected as early as 4 to 6 weeks do not always grow as expected, a further selection is desirable at about 20 weeks and just before they go to the breeding pens.

Feathering

Processors demand broilers that are uniformly covered with feathers. Because the sex-linked factor for feathering is inherited in such a simple manner, it is highly improbable that any reputable strain does not already contain a large proportion of early-feathering stock.

The method used is to select chicks for fast feathering at a day old and later to select growing chicks for rapid growth and for superior meat production. Selection is applied to both males and females and to the parental stock producing crossbred broiler chicks.

Selection to obtain breeders that feather rapidly is most easily accomplished at the time of hatching. Fast feathering is a sex-linked recessive to slow feathering; hence, when mated together, male and female breeding birds selected

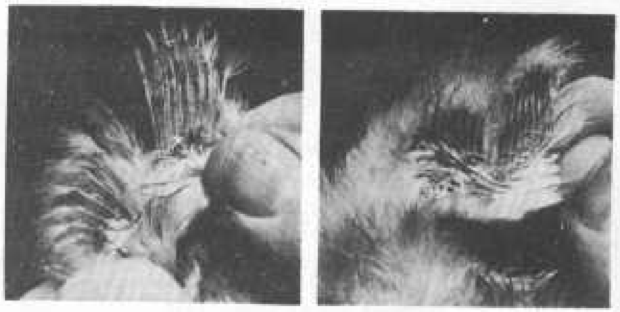

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FIGURE 3.—Fast feathering: Left, wing of chick with seven primary and seven secondary feather sheaths, all of which are nearly equal in length; right, wing of another chick with similar development of feather sheaths.

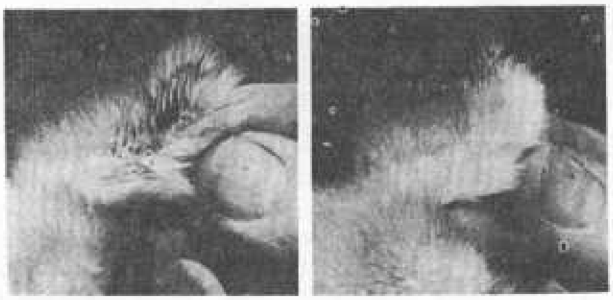

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FIGURE 4.—Slow feathering: Left, wing of chick with few primary and secondary feather sheaths; right, wing of another chick with short primary and no secondary feather sheaths showing through down.

for fast feathering will produce fast-feathering chicks.

Rate of feathering can be determined in day-old chicks by the length of the primary and secondary feather sheaths of the wing and the number of the secondary feather sheaths. The chick with the highest rate has well-developed primaries and secondaries, with six or more secondaries (fig. 3, left). The next best has six or more secondaries, which are not so well developed but are approximately as long as the primaries (fig. 3, right).

The chick of the slow-feathering type has no secondaries, or less than six short ones, and no primaries, or very short ones. Figure 4 illustrates slow-feathering chicks. About 90 percent of such chicks feather slowly, have no tail-feather development at 10 days, and small primary and secondary wing-feather development (fig. 5, left). Some of them will develop into "barebacks" at 12 weeks of age, and many of them will have a considerable number of pin-feathers. These are not good breeders with respect to feathering. In this group the males, in particular, should not be used as breeders.

When selection is made of fast-feathering chicks (fig. 5, right), they should be raised by themselves, or if this is not feasible, they should be identified by some means. Wing banding is considered the best and most permanent means of identification. If this is not practicable, then the chicks may be toe-punched, or a pair of scissors may be used to cut the web between the toes. In any case, some means should be adopted so that such chicks can be recognized at a later age.

Breast Development

As the breast meat is the most valued part of the broiler, this characteristic should be given considerable attention in any selection and breeding program. Observations of breast development should be made when birds are 6 weeks of age, but may be made when they are from 6 to 12 weeks old. For these observations each bird should be examined individually and held in a similar position. A good way is to hold the chicken by the legs in the left hand, with its head downward, and with the right hand to examine the width and length of the breast. By comparisons, the birds can be divided into at least four grades, as shown in figure 6.

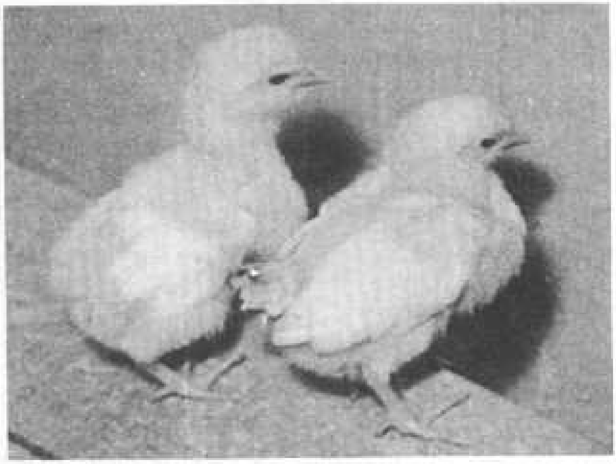

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FIGURE 5.—Chicks showing contrasting feather growth: Left, slow feathering at 10 days of age; right, fast feathering at same age.

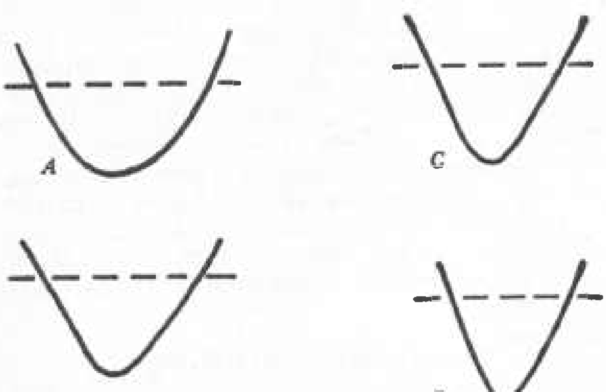

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FIGURE 6.—Breast types and grades of birds to be selected as breeding stock for broiler production: *A* and *B* show desirable fullness of breast; *C* and *D* are poorer types. (Observations made about three-quarters of an inch from edge of keel.)

At this time observations may be made also on any imperfections of the breastbone or skin, such as curved and dented breastbones and breast blisters. Any individual with such imperfections should not be used as a breeder. With a little experience one soon learns to judge accurately the relative breast development in birds of the same age.

The different breast grades represent measurements used in poultry meat-production experiments at the Agricultural Research Center, Beltsville. This method of classification permits four grades—A, B, C, and D. If one wishes further divisions, grades A+, A, A—, B+, B, B—, and so on can be used. Only males with A or B breasts and females with A, B, or C breasts should be kept for breeders.

One of the best times to select breeding birds for efficient, rapid growth is at 6 weeks of age, and it is also an ideal age to observe breast development. As both of these observations may be made at this time, one handling of the birds is eliminated.

Shank Pigmentation

Shank pigmentation is inherited. Within the yellow-skinned varieties there are distinct differences ranging from bright yellow and orange yellow to green and sometimes bluish shades. This has not been of sufficient value economically to justify much consideration. Nutrition and freedom from parasites and diseases affect pigmentation much more than inheritance.

Diseases (General)

Chickens differ genetically in their ability to resist invasion by protozoa, bacteria, fungi, viruses, and parasitic worms. It is feasible to develop strains comparatively resistant to *Eimeria tenella* coccidium, fowl typhoid, pullorum disease, visceral lymphomatosis, Newcastle disease, "blue comb," and encephalomalacia. However, it has not been determined whether it is economically feasible to do so in any case.

When severely exposed to respiratory disease, the strain cross progeny of good noninbred strains fared better than their pure parent strains.

The S6 strain of avian pleuropneumonialike organisms (PPLO) *Mycoplasma gallisepticum*, an agent, or one of the agents, in the air-sac disease complex or airsaculitis, is present in most broiler breeders. The ultimate objective is to eliminate the infectious agent from breeder flocks. A blood test can be used to detect noninfected flocks. It has no value in detecting individual birds, as in the pullorum test. Dipping eggs in antibiotic solution can help in reducing PPLO in breeders, but is of questionable value in the routine treatment of eggs for broiler production.

As airsaculitis is the largest single cause of condemnations, the elimination of PPLO from breeders is very important. Foundation breeders should assume the responsibility for cleaning up all their breeder flocks. Both male and female lines must be clean. In order to facilitate the development of "clean" flocks, breeders may, with insignificant genetic loss, relax selection for 8- or 9-week body weight for one generation.

Both broiler breeder replacement and broiler chicks should be from parent stock free of PPLO. Therefore, in commercial production of replacement stock, reasonable geographic isolation of serologically tested negative birds is important. Special precautions should be taken to see that management isolation is not disrupted at any time.

Leukosis

The amount of leukosis in broiler condemnations and total mortality are often masked by conditions such as septicemia and airsaculitis. There is no practical test by which the infected hen, egg, or chick can be detected. A hatchery should not accept eggs from a breeder flock with a high incidence of leukosis.

The ability of certain strains of birds to resist the virus that causes visceral lymphomatosis, the most prevalent form of leukosis, has been shown to be due to genetic factors. Culling of flocks is most effective if done on a family basis, and entire families with individuals showing indications of the leukosis complex, such as irregular pupils, marble bone, or other symptoms, should be eliminated. A highly susceptible strain should not be used for crossing purposes. Since the disease can also be transmitted by direct contact between chickens in the same hatching or rearing units, isolation procedures are essential. There is no known treatment for leukosis.

Nutrients

The requirement for certain amino acids—arginine, methionine, but not lysine—is inherited. Genetic differences have also been exhibited for the A, B_1, D_3, E, and riboflavin vitamin factors, the unidentified growth factors, manganese, calcium, and zinc. Again, selection for rapid growth normally emphasizes the individuals most capable of efficiently using these nutrients and leads to the elimination of those having an abnormally high requirement for them. Basically any individual with an abnormal requirement for any nutrient should be eliminated as a breeder.

Plumage Color

Growth rate and other characteristics may be affected by the genes that determine plumage color of broilers. For example, the gene for silver

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FIGURE 7.—White birds, with Cornish and White Plymouth Rock strains predominating, make up most broiler breeding flocks.

apparently has to be associated with the gene that extends black and with recessive white for maximum growth. If white birds are desired, the dominant white gene needs to be combined with the gene causing barring.

Color sex-linkage for determining sex at hatching has not made progress because the females are not white. Processors want all birds to be white (fig. 7).

Egg Size

Broiler chicks from large eggs (24 to 28 ounces per dozen) are definitely larger at hatching than those from small eggs (18 to 22 ounces). As broilers grow, the effect of this relationship is less, but it is still definite at 8 and 12 weeks for body weight and possibly for feed conversion. The trend in early chick mortality is high in 18- to 21-ounce eggs.

When hatching eggs are scarce and more small eggs are set, broiler raisers observe that mortality tends to increase and growth and feed conversion suffer. In independent operations, broilers from larger eggs usually bring a greater cash return per bird over feed costs. However, in an integrated operation, broilers from smaller eggs may give greater total returns over egg and feed costs.

HOUSING

Location

A minimum of 5 acres of land is usually needed for a specialized broiler enterprise. The broiler house should be located where water drainage and air movement are good. Low lying, damp areas and valleys should be avoided. Usually an open area, free from trees, is better for naturally ventilated houses. However, for southern areas, a row of tall trees on the south side of the house, with branches above the eave line, may be desirable for shade. Most houses are oriented in an east-west direction.

The cost of house construction is higher if the land is not reasonably level. Usually it costs more to prepare the site for one long house than for two short ones. To avoid dampness, the floor of the house should be a minimum of 6 inches above the ground level, and higher is desirable. There needs to be a good access road from the houses to the highway because of feed and bird haulage. The cost of getting utilities, such as water, gas, and electricity, should be considered. A location should be avoided where the birds may be disturbed by automobile lights. Houses should be convenient to the caretaker's house, and the prevailing wind should be away from his house.

Requirements

A broiler house should provide clean, dry, comfortable surroundings for birds throughout the year. The house should be kept warm enough, but not too warm. The litter should be kept reasonably dry. Provision should be made to modify the air condition as broilers grow. Fresh air should be circulated, but the house should be free from drafts. Results are not so satisfactory when the broiler house is too cold, too hot, too wet, or too dry.

The importance of adequate housing to protect broilers from adverse conditions is apparent from the seasonal effects on broiler results. Mortality, condemnations, and medication costs are highest and feed efficiency is usually poorest in birds sold during the winter. Growth is best in the fall. Feed efficiency is best in birds sold in the early summer. Medication costs are also lowest in the early summer. Hot weather adversely affects both growth and feed efficiency.

Ways by which a grower can decide on the kind of broiler house and equipment in which he will invest include personal experience and experience of neighbors and friends; advice of the serviceman, the contractor, and builders; and information from the county agent, extension service, and poultry press. He must decide on how much capital he can invest, the size of broiler unit he needs or can build, and the most economical facilities in terms of expected results. The integrator may have some requirements as to the size and type of the broiler unit. For the importance of fixed costs in relation to labor income, see pages 7–8.

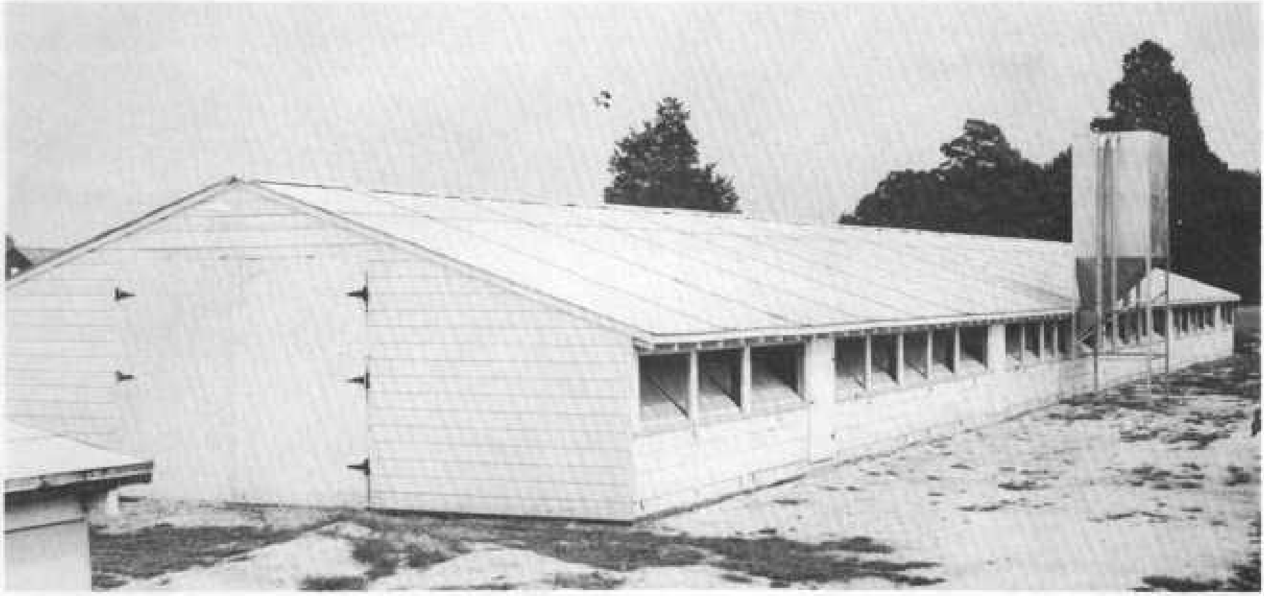

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FIGURE 8.—Typical broiler house in Delmarva area. Note outside door for each pen, large double end doors, outside centered feed storage, and white roof.

Types of Houses

Pole-type houses are economical to build, maintain, and clean. Pressure-treated poles are set into the ground to support the roof and the walls. Pole-type houses usually have roofs of metal and walls of poultry netting covered with curtains or with conventional building materials and curtains. If panels are to be used, the more conventional construction with a foundation and studs is preferable.

In broiler-producing areas where winters are cold, the better broiler houses will have insulated ceilings and walls. Often they have central heating and may have controlled fan circulation.

In areas with warm winters, houses are usually less solidly constructed. As a result, production costs may be higher in both winter and summer. More attention is being given to both insulation and ventilation in all areas.

In the South, extreme heat and occasional severe cold are both problems. Some wide-open houses are being modified to include at least roof insulation and adjustable curtains. More attention is being given to having enough heat when it is needed, so that adequate ventilation can be provided.

Broiler houses in the various areas are of many types and dimensions and are constructed of many kinds of materials. In the North, concrete floors are usual, whereas in the South, they are rarely found.

Many of the new houses are 24 to 40 feet wide, with gable-type roofs. The consensus is that the best broilers come out of relatively narrow houses —24 to 30 feet wide. Wider houses are more economical to construct (see p. 16). Construction is usually either the pole or combined pole-stud type. The length varies from 200 to 600 feet, with most of them from 300 to 400 feet. For ease in using 4- by 8-foot sheets of insulation, houses are often built in multiples of 4-foot lengths. If houses are too long, the cost of preparing the site, especially in hilly country, may be too high. The capacity of new houses usually varies from 7,200 to 20,000 broilers. All the birds may be in one pen, or pens may have as few as 1,000 birds. The trend is to pen units of 1,200 to 2,500 birds.

Sidewall height in houses is usually 6 to 8 feet. If there is no ceiling or insulation is placed on the underside of the rafters, a 6-foot height will normally give adequate headroom for cleaning equipment and sufficient opening for natural ventilation. Roofs are usually of galvanized iron or aluminum, with insulation or 15-pound asphalt felt under them.

If on-the-job constructed ridge ventilators are used, the north side is usually closed and the south opening can be closed when desired. Many new houses have one 4-foot long, rectangular, prefabricated metal ventilator per 1,000 broilers. It can be adjusted by means of a chain or rope so that it can be wide open, entirely closed, or one side can be open at any time.

It is usual to have double doors at each end so that a manure spreader or truck can be used for litter handling and for cleaning the house. The doors can also be used for added ventilation in

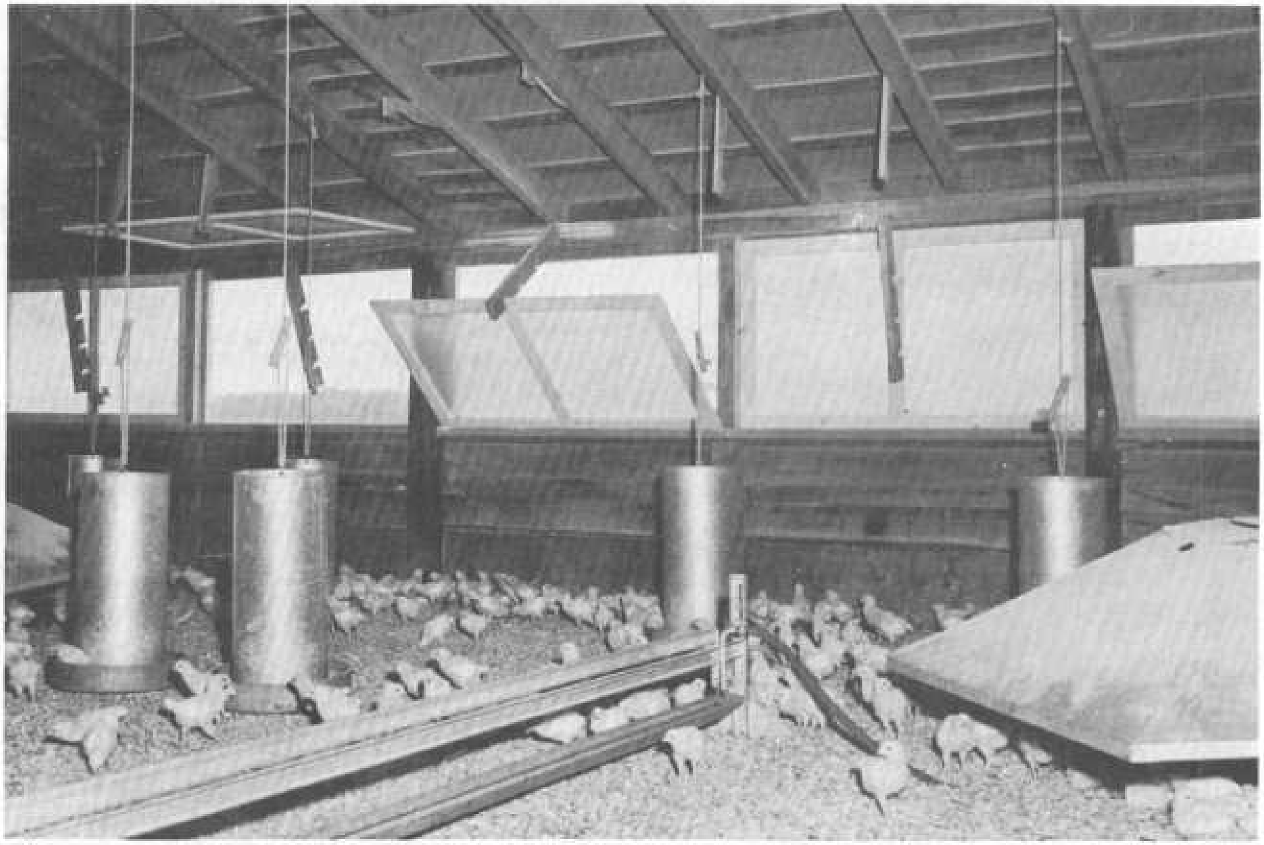

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FIGURE 9.—Brooder house. Note removable adjustable window panels, canopy hover, hanging feeders, and floor-type waterer.

hot weather. Each pen has a wide door on the outside wall to aid in loading birds going to market. (Fig. 8.)

The overhang at the eaves is usually 2 feet. Windows or upper openings may have panels covered with various curtain materials or curtain materials without frames. The upper panels may swing in at the top, with or without hinges (fig. 9). The lower openings of this house may be closed with curtain material or panels or be winterized with 15-pound felt. These lower panels, when used, swing out. The lower panels may be covered with metal, wood, insulation material, or curtain material, similar to the upper frames. Winches and cables are often used to control panels from a convenient point in the house (fig. 10). All openings to the house should be covered with ¾-inch mesh wire to keep out wild birds.

Although maintaining adequate temperature is of first importance, constant attention is needed to ventilate the broiler house properly. In general, narrow houses are easier to ventilate. **Attention should be given to weather forecasts,** especially of windy weather, so as to anticipate the need for quick adjustments of frames, curtains, or panels. Drafts that might chill the birds should be avoided. Enough circulation should be maintained to keep the litter dry. Young chickens are often overventilated. For information on environmental control, see page 15.

To get the best broiler performance, the house should be as warm as possible without stressing the birds. They should be kept as comfortable as is economically feasible. There should be no unrepaired holes in the walls or roof, no misfitting door and panels, nor too much window opening.

Insulation retards the flow of heat and helps maintain a more desirable temperature in the house. It is much easier to control the temperature and ventilation in a house if it is insulated. The way the house is managed will, to a considerable extent, determine whether the insulation is of value. It may be as important as the "R" values supplied. Insulation materials vary in effectiveness and cost. They should be economical, efficient in stopping the flow of heat, reasonably permanent, easy to apply, able to resist wind and fire, and resistant to wetting. They should not warp and should resist rodents and insects. They should not be used in the lower part of the house

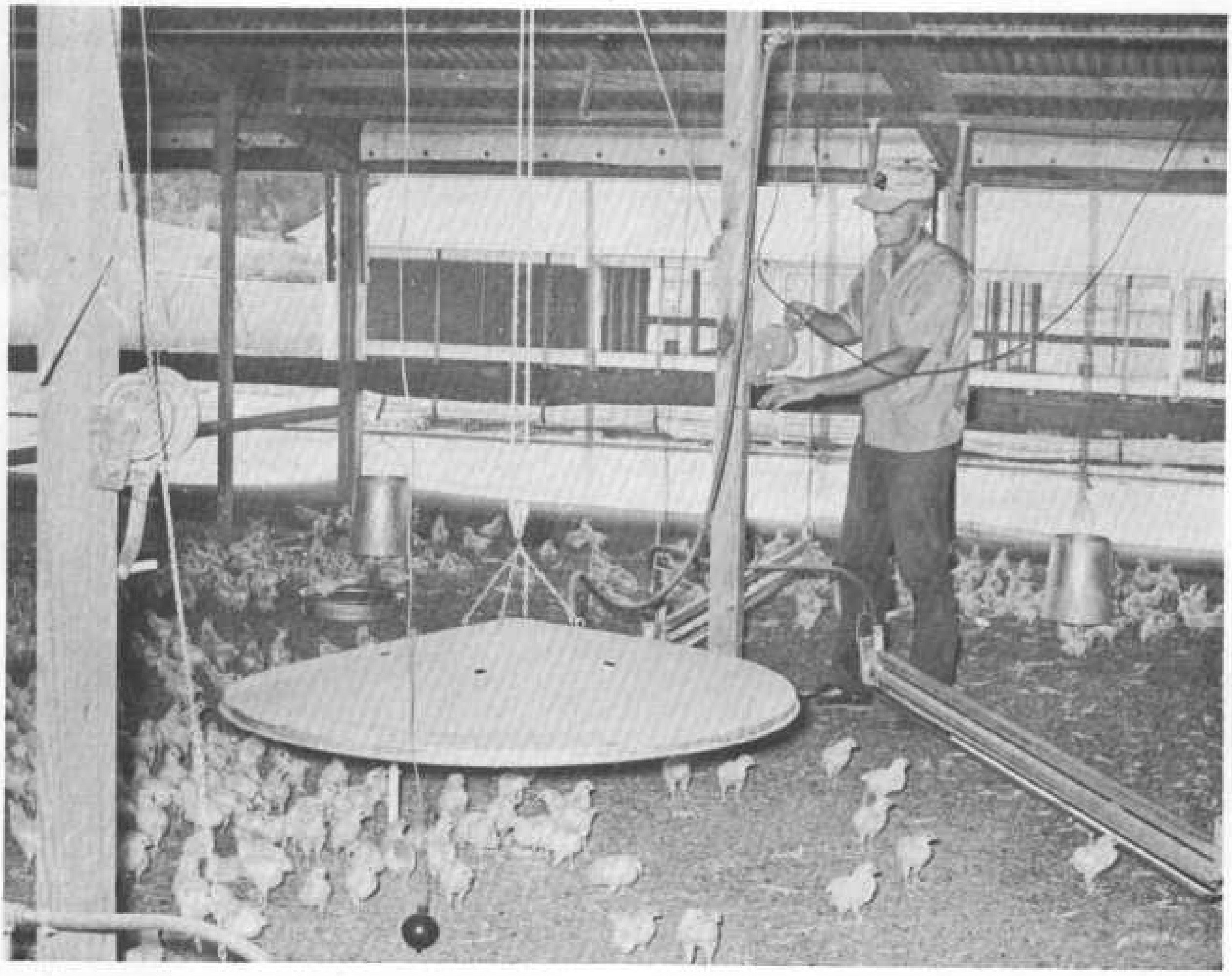

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FIGURE 10.—Broiler raiser adjusting height of "pancake" brooder. Winches can be used to regulate height of curtains. Note hanging waterers and feeders and feeder pan still in use.

without protection, unless they are peckproof. Some materials have reflective properties as well as built-in vapor barriers. To be effective, reflective surfaces must be exposed to the air space.

The general rule for ventilation in the space between the roof insulation and the roof is to provide openings equal to one three-hundredths of the building floor area. This type of ventilation could consist of openings along the eaves above the insulation and some ventilators in the ridge or gable ends of the roof.

Controlled Environment

The primary objectives of using windowless, fan-ventilated, insulated broiler houses are as follows: To provide a more desirable temperature, to furnish an adequate supply of clean fresh air without drafts during the winter, to create with turbulent airflow a comfortable condition for birds in hot weather, to give more positive ventilation, and to make management easier by reducing the time and some of the drudgery required to care for the birds properly. The final result is an improved market quality of birds and higher income.

A correctly designed and properly adjusted air-inlet system is important in attaining these objectives. A proven system should be used or an engineer consulted. The operator usually sets the timeclocks and thermostats once a week according to the age of the broilers or the desired temperature and more often when there are extreme weather changes. It is essential not to throw away needed heat by excessive use of fans. About 25 percent of the maximum capacity of the ventilating system is operated continuously without controls. Mechanical ventilation and insulation will not solve the problem of poor management; they may add to it.

While the brooders are in operation, the thermostats are set in relation to their heat output. The thermostats for the heating and the ventilating systems must be synchronized so they are not operating in opposition to each other. Most of the mechanically ventilated houses are being constructed so the sides can be opened. Winter results have beeen rather uniformly good, but in some cases, sidewall panels have had to be removed during the hot periods of summer. Emergency electrical power units seem to be necessary because of high or total losses in case of power failure. The use of electricity for the fans can be estimated at about 250 kilowatt-hours per 1,000 broilers per batch in the fan-ventilated houses. Controlled mechanical ventilation is usually installed in houses that are insulated and in which the normal bird density has been increased by 20 to 25 percent. For forced ventilation, fans should be selected and controlled to deliver from 1 to 3 cubic feet of air per minute per broiler against ⅛-inch static pressure.

The balance between insulation, forced ventilation, amount of air infiltration, and variable temperature outside must be maintained. Undesirable air conditions in the house may result if any factors are not stabilized. The higher initial operating cost of the windowless house must be justified in terms of the claimed advantages. Consideration also must be given to the need for more technical skill than is possessed by the growers on many broiler farms. This skill can only be gained through experience.

To maintain a balanced environment for broilers, prevailing and forecasted atmospheric conditions of temperature and humidity should be considered. Fans are being used in broiler houses to help force the required air through the house in order to remove polluted air, dust, and the moisture evaporated from droppings, from around waterers, or from rain entering the house. The fan and blower assemblies and their controllers and protective equipment should be selected to meet the particular airflow requirements of the situation. It should be possible to provide at least 3 cubic feet of air per minute per broiler. Poultry-house fan motors must be totally enclosed because of the dust, moisture, and ammonia fumes. In well-insulated houses, filled to capacity with birds, more air can be moved to remove moisture without seriously lowering the temperature. A room temperature of 60° to 70° F. is generally desirable.

Housing Costs

Research is needed to find out what housing costs are justified. In the meantime, some factors to consider in choosing between low and high initial housing investment are as follows: Current and probable future costs of construction, probable differences in growth and feed conversion, lower mortality and condemnation losses, interest rates, repair costs, taxes, risk, and prestige.

The housing and equipment costs amount to 5 to 6 percent of the total cost of production. They range from about 50 cents to $1 per square foot of floor area for the open-type house characteristic of the southern broiler areas to about $1 to $1.50 per square foot of initial investment for houses insulated overhead, ventilated with fans, and thermostatically controlled. There has been a marked increase in the width of houses and the use of insulation, especially under the roofs, in most broiler areas. Wider houses cost less than narrow ones per square foot of floor space, because there is less sidewall to enclose and they have the advantage of having less exposed area through which heat will be lost. In general, the more the investment in housing, the lower the fuel and repair costs.

With better equipment, labor costs are usually less. If the watering system is well planned, the waterers can be easily cleaned. If it is easy to medicate the water, much labor can be saved. However, the cost of production can be high if facilities are not fully utilized. Using houses on as nearly a continuous basis as possible and filling them to capacity at all times are the main ways to keep housing cost per bird low. For the effect of fixed or housing costs on labor income, see page 7.

When estimating the percent cost of materials for a pole-type insulated house with a concrete floor, the lumber to frame the structure will be about 25, the covering materials about 40, insulation 20, and concrete floor 15. If labor is estimated at about 40 percent of the total building cost, the materials for the structure will be reduced to about 15 percent and the covering materials to 25 percent. Care should be taken in modifying plans to reduce costs. The saving may be lost because of increased cost of repairs and maintenance and decreased life and safety of the building. Engineering assistance should be requested before too much modification is attempted from proven plans.

It is possible to use table 2 (p. 30) to estimate the possible advantage of using insulation in the broiler house, or otherwise building a house that will result in an improved feed conversion. If we assume a broiler at market age weighs 3.33 pounds and has a conversion of 2.4 pounds and feed is $4.50 per hundredweight, the feed cost of the broiler is 3.33 times 10.80 cents (table 2), or 35.96 cents. If the feed conversion is 2.3 pounds, the feed cost per broiler is 3.33 times 10.35 cents (table 2), or 34.46 cents. The feed-cost saving *per broiler* for each 10-point saving in feed conversion is 1.5 cents (35.96—34.46). The feed-cost saving *per pound of live broiler* for each 10-point saving in feed conversion is 0.45 cent (1.5÷3.33).

Allowing 0.8 square foot per broiler and four broods per year, about 16.5 pounds ((3.3×4) ÷0.8) of live broiler are produced per year per square foot of broiler house. If the saving per pound is 0.45 cent, the saving on the 16.5 pounds of broiler weight per year would be 7.4 cents (16.5×0.45). Allowing 10 years as the normal life of a house for depreciation purposes, 74 cents (7.4×10) per square foot could be expended in housing costs for each 10-point anticipated improvement in feed conversion based on $90 per ton of feed.

It would seem that some houses could be changed with profit when there is a possibility that improvement would result in better feed conversion. Research is needed to determine the economics of housing in relation to livability and condemnations and also on how to manage houses so as to use environmental control effectively.

BROODING

Brooding Systems

Adequate temperature is the most important factor in successful brooding, because without it adequate ventilation in the wintertime is impossible. It is possible to raise broilers with many types and makes of brooding equipment. Some of the factors to be considered when deciding on the system of brooding to be used are the availability and cost of the fuel, the size and construction of the brooder house (fig. 9), especially as to whether or not it is insulated, the convenience of operating the equipment, and the ease of removing the hover when cleaning out the house. It is assumed that only those types of brooders will be considered that will give good broiler performance.

The initial investment is greater when central brooding systems for either hot water or hot air are installed than when the canopy hovers are used. The cost of operation is usually less. They are more economical to operate in units of not less than 3,000 broilers. The hot-water brooding system responds more slowly but holds its heat longer than the hot-air system. This might be of advantage in case of power failure if auxiliary power is not available. Central heating systems offer less fire hazard than the canopy hovers, except those using electricity as the energy source. They are more easily controlled by thermostats and other automatic devices because fewer are required. However, inexperienced operators may not be able to maintain as uniform temperature under the brooding canopy or areas. The usual fuels for central systems are natural or liquefied petroleum gas, coal, or oil.

A central heating system should be designed by a qualified person for the building in which it is to be located. Hot-water systems were used with pipes laid in the floor. They proved less efficient and otherwise less satisfactory than when pipes were laid above the floor and are rarely used commercially now. The above-the-floor hot-water system usually consists of a horizontal bank of six pipes of 2-inch inside diameter, or smooth black water pipes, or a few combinations of alternate sections of "fin" and smooth black pipes with equal heat output. Vulcan, or fin, pipes have about five times the radiation of smooth pipes, but are more difficult to keep clean and lose some of their effectiveness when dirty.

A hover is usually formed over the pipes. It may consist of reflective-type insulation, plywood, 15-pound felt, or some other material, placed on wood or insulated strips spaced along the pipes. It is used while the chicks are small. Litter is sometimes used on top of the hover, but is not very satisfactory.

A forced hot-water circulation with circulatory pumps is generally used because it responds more quickly to the thermostat than the gravity-flow hot-water system employed in earlier installations. Automatic controls consist of an aquastat to regulate the fuel intake and the thermostat to control the circulating pumps.

In the warm-air system there is a centrally located warm-air heater, from which warm-air pipes run each way to a series of hovers. The warm air is forced through the heating ducts by a blower. The returned air is wholly or partially drawn from the heated pen. The system is controlled primarily by thermostats placed at the far ends of the brooder house. The principal disadvantage is that, in case of a power failure, there is no heat available when the blowers stop operating. Otherwise, there is no reason why equally good results cannot be obtained with either system.

When an insulated mechanically controlled house is used, the need for a central brooding system may be more difficult to justify. One of the principal reasons for the central systems is the more favorable room temperatures that can be maintained in both insulated and non-insulated houses.

For commercial broiler production, the 1,000-chick hover should be the choice over the smaller hover whether heated by gas, oil, or electricity. The gas used may be natural or liquid petroleum

(LP). The gas hovers come in canopy or infrared types. It is usual to allow 10 square inches of canopy hover space per chick. For winter brooding in noninsulated houses, not over 750 chicks per hover are recommended. In insulated houses, allow 850 chicks per hover. In mechanically ventilated insulated houses, it may be possible to start 1,000 chicks under a 1,000-chick canopy hover, allowing only approximately 7.3 square inches per bird.

Fuel consumption should be considered when comparing canopy and infrared-type gas hovers. Gas hovers are usually easy to regulate and relatively inexpensive to operate. They may not provide enough heat in extremely cold weather. Like oil and electrically heated hovers, most gas hovers are cold-room brooders and do not heat the room to the extent that may be desired. This is particularly true in noninsulated houses, especially those with considerable air leakage (ridge ventilators with open sides, or poorly constructed panels and walls, or both). In insulated houses, gas hovers often do not heat the room to the recommended temperature without maintaining too high a temperature under the hover. A warm-room, gas-burning hanging brooder, often referred to as the "pancake" type, is now being used (fig. 10). It helps to raise the room temperature.

Gas and nonvented oil-burning hovers also have a disadvantage of giving off moisture as well as gases into the house. Every pound of liquefied petroleum gas (LPG) burned will give off 1.6 pounds of water, 3 pounds of carbon dioxide, and some monoxide gas. Every pound of fuel oil gives off 1.2 pounds of water, 3.1 pounds of carbon dioxide, and some monoxide gas. For each pound of LPG or fuel oil burned, it requires about 300 cubic feet of air at 60° F. to remove the water and gases. A gallon of LPG weighs about 4½ pounds and has approximately 80,000 usable British thermal units (B.t.u.) per gallon. A gallon of fuel oil weighs about 7 pounds and has about 100,000 usable B.t.u. per gallon. The 1,000-chick brooders have heat outputs that range from 12,000 to 30,000 B.t.u. per hour.

LPG is extensively used as a fuel for brooders. Propane and butane are its main constituents and LPG is usually a mixture of them. During low-temperature periods, butane might not vaporize fast enough to furnish vapor for the needs of the brooder, whereas propane might furnish the required amount. Propane develops about the same tank pressure at −10° F. as butane develops at 70°. Therefore, gas suppliers regulate the ratio of butane and propane in the fuel to provide satisfactory operation at different atmospheric temperatures. They also add alcohol to the fuel during cold weather. At all times sufficient air must be supplied to the burners to get enough oxygen for complete combustion.

At one time coal-stove hovers were very popular in the North and East. They were excellent for winter brooding, but were difficult to regulate in mild and hot weather. Oil brooders are satisfactory, if the oil is reasonably priced. There are two types, one with and one without vent pipes. When wood is available and cheap, the wood-burning hover is satisfactory. However, few are used any more because of the labor involved. Electric hovers are not extensively used. In areas where either coal or oil is available and cheap, supplementary heaters are often used effectively in cold weather to give extra needed heat when gas and electric hovers are used. Because they are cold-room brooders, gas and electric hovers do not materially heat the room. Consideration should be given to the relative economy of using supplementary heat, more hovers with fewer chicks per hover, or larger canopies with more space per chick.

Environmental Factors

Careful management is necessary to give as good air conditions as possible for temperature, ventilation, and humidity. The action of the chicks in itself is not, at all times, an adequate guide to temperature. With multiple-unit or large brooders, it is not possible to judge the temperature of an individual hover by the position of the chicks around it. Each hover should be equipped with a thermometer. The temperature should be read once or twice daily, depending principally on the room temperature and the age of the chicks. The necessary adjustment should be made. The brooding equipment should be capable of giving enough heat at all times.

The recommended temperature **at chick level at the edge** of the hover is 95° F. for the first 2 days, with a reduction of 3° daily for 5 days to 80°; second week, 80°; and from the third week on 75°. Avoid any temperature below 60°. For the best feed efficiency with good growth, and especially when there is any sickness present, a room temperature of 75° is recommended. When chicks circle wide or leave the hover, it it too hot or the room temperature is comfortable. If they tend to crowd under the hover, it is too cool. In either case, the temperature is probably extremely high or extremely low and adjustment is needed immediately. Avoid especially temperatures below 80° the first 2 weeks and over 85° after 6 weeks. Avoid wide daily fluctuations of 20° to 30° in the first 6 weeks. Temperature fluctuations should be watched, especially when you are trying to brood without heat in warm weather.

With uninsulated houses, the heat requirements will be greater than with insulated houses, provided the advantages of insulation are not dissipated by excessive air leakage through open or leaky walls, uncontrolled ridge ventilators, or in similar ways. The outside temperature is a considerable factor in heat requirements and is one of the reasons why winter broods are usually less profitable than those at other times of the year.

If everything else is normal, the chicks will be comfortable when the relative humidity is 50 to 70 percent. They may show discomfort by huddling at 45 percent or less when the room temperature is 60° to 70° F.

Insulated houses can be ventilated less than noninsulated houses and still maintain good conditions. The reason is that more moisture is removed per pound of ventilated air at higher temperatures in insulated houses than at increased ventilation at low temperatures in noninsulated houses.

In insulated houses, ammonia may be more of a problem because of insufficient ventilation. In uninsulated houses, ammonia is partially combined with condensing moisture.

An adequate source of heat helps to provide adequate ventilation. Often a broiler house is closed tight with plastic to conserve heat. As a result, the air becomes foul and the litter wet. With inadequate ventilation, ammonia may build up to the extent that the eyes of the chickens and the grower are affected. Chickens affected by ammonia will jerk their heads as if to clear them. This production of ammonia depends on the amount of fecal matter in the litter, litter moisture and temperature, litter aeration, and possibly the porosity of the litter. When the air is below 32° F., there is no noticeable ammonia. Above 32° and with litter-moisture content above 29 percent on a dry basis, ammonia production is noticeable.

The chicks may be chilled if there is too much ventilation. Overventilation that disperses needed heat is costly. A draft or a wave of cold air directly on the birds should be avoided at all times. Correct ventilation is an individual problem. Vented central heating systems do not put additional moisture into the room as do nonvented gas and oil-burning hovers and require less ventilation to remove the moisture. The heat output of broilers after they are 6 weeks of age is many times that of baby chicks. This is true of moisture output. Ventilation must be stepped up as broilers increase in age and weight. Because needs fluctuate so, the grower should be present in order to give attention to each situation as it arises. Neglect of the flock can mean a stress on the birds, which can result in colds and chronic respiratory disease complex, in spite of previous careful attention.

Wet litter is never desirable. It can be the source of disease outbreaks or breast blisters. Excessive dust may trigger a respiratory trouble. Both conditions can be avoided with proper ventilation made possible by adequate heat. Dust has sometimes been a major problem with fan ventilation, probably because of lower humidity and overdrying of the litter.

If broiler houses are equipped with winches and cable (fig. 10) to quickly and effectively adjust frames and curtains, the houses will often be better ventilated. It is even better if the grower stays around the houses and spends plenty of time with his birds, so that he can anticipate the required action.

For information on the size and type of house, insulation, mechanized ventilation, and use of fans, see page 13.

Hot-Weather Problems

The heat given off by a thousand chicks at a day old is only about 3,600 British thermal units (B.t.u.) per hour, but at marketing age (3.3 pounds) it is 42,900 B.t.u. per hour. Temperatures from 85° to 95° do not markedly affect growth and feed efficiency in chickens up to 6 weeks of age unless the humidity is also 55 percent or higher. Above 95°, heat prostration may occur, especially at 75 percent relative humidity or higher. At any humidity, the 6-week-old and older broilers start to suffer at 85° and over, and heat stress occurs.

When drugs are used in the drinking water, the dosage prescribed is based on normal water consumption. High temperatures will result in high water consumption, which may give an overdose of the drug. Conversely, low temperatures result in low water consumption, which may give an underdose of the drug.

In addition to high temperature and humidity, the stress can be increased by having deep litter, insufficient water, too shallow water in waterers, overcrowded birds, weeds outside the house so high they cut off air circulation, and by doing nothing to relieve the condition. Whitewashing or painting the roof aids in heat reflection. Water sprinklers on the roof will reduce the roof temperature and therefore the radiation of the heat from the roof. Increasing the turbulence of the air by increasing air circulation by natural or artificial means will reduce the body temperature and respiration rates.

Deep, cool, clean drinking water should be provided. For water-consumption rates, see page 37. Water consumption at 95° F. is at least double that at 70°. Be sure the birds do not run out of water at any time. At least four 8-foot waterers per 1,000 broilers should be provided when the temperature is above 90°. During hot weather, the use of lights becomes especially important, as birds will eat better during the cooler hours of the night than during the hotter hours of the day. Keeping the litter shallow helps to avoid some of the heat of fermentation, which results with deep litter, and also the birds can come in contact with cooler soil and lose heat from their bodies by conduction.

Litter

The usual kinds of good-quality litter apparently do not affect growth, feed conversion, or mortality under general growing conditions. A good-quality litter is dry, loose, and absorbent. It should contain no injurious materials or molds and be reasonably free of dust. Convenience and economy are important considerations. Shavings are the most popular litter, with sawdust second. Sawdust should be covered for 3 days, as young chicks sometimes eat it. Peanut hulls, cane pulp, rice hulls, flax, peat moss, wood chips, and ¾-inch pine-bark litter can be used. Crushed corncobs may cause more breast blisters than other litters. Excelsior waste tends to mat and cake. Chopped straw, about 6 inches deep, is preferred for large broilers and roasters to prevent breast blisters.

To prevent disease from being tracked into the house, the house should be locked after clean litter is in place. A shallow pan of disinfectant should be placed at any entrance in use. The disinfectant should be kept reasonably fresh and undiluted.

Litter can be reused provided a severe disease outbreak has not occurred. It is usually economical to do so. Growth, feed conversion, and market quality, other than breast blisters, are not usually affected, provided the litter is in good condition. The prevailing broiler price, the cost of the new litter, the value of the used litter as fertilizer, its condition, and the cost of and the time required for removing the old litter are important considerations. A cushion of clean, dry litter is the best insurance against breast blisters. If litter is replaced, usually 1 week is allowed between batches for cleaning out and 1 week for the pen to remain idle.

Wet or caked litter may be due to starting with less than 2 inches of litter. It causes stresses that may lead to poorer results. Usually more breast blisters occur with wet litter. Some nonspecific enteritis and mycosis may result from moldy litter. To avoid excessive moisture, good management must be practiced. Ventilation must be sufficient and proper. The house temperature must be adequate. Waterers must be kept adjusted to avoid spillage and in good working order to avoid leaks. Stirring damp litter prevents caking in the winter. Between broods, caked and wet litter should be removed from the house.

Some of the risks of not cleaning out after every brood include more losses, due especially to chronic respiratory disease (CRD), leukosis, and aspergillosis. There may also be more roundworms, tapeworms, and coccidiosis. On the other hand, losses from avian nephrosis (Gumboro disease) may be as high or higher if the litter is changed. With thorough disinfection, security management, and replacing old with new litter, mortality may sometimes be materially reduced, even when avian nephrosis is the problem.

The cost of removing old litter and adding new varies considerably. In commercial practice, much hand labor is now replaced by use of various kinds of mechanical equipment, including power loaders, bulldozers, manure spreaders, and front-end loaders.

Deep litter is especially important on dirt floors, because if it is dry, it will prevent penetration of the cold from the ground during the low-temperature periods. In the winter at least 6 inches is desirable. Two to four inches is usually a good depth for the summer. The availability and the cost of litter become factors (see p. 8).

Preparation of House and Brooder

One of the most important ways to prevent and reduce losses from disease is a strict security management program. In addition to the general sanitation program (p. 26), certain specific things should be done in preparation for and during the brooding phase.

The primary objective is to break the cycle of infection. Every bird should be off the farm before the cleanup process starts. **Remove all feed from feeders.** All removable equipment, such as hovers, feeders, waterers, and stands, should be swept free of dust, washed clean under pressure, disinfected with an approved disinfectant, and put outside in the sun while the house is being cleaned. Do not overlook the baby chick equipment, especially fountains. Equipment that is raised while the litter is removed should be washed and disinfected before fresh litter is added. Nothing should be overlooked. For disinfectants and insecticides, see pages 26–27.

A concrete floor is easier to clean than a dirt floor. When the latter is used, it is preferable to clean out all the old litter after each brood. Put in 2 inches (4 inches in winter) of new, clean, dry litter. When this is not considered to be necessary or advisable because of relatively little trouble from diseases or parasites, high cost of litter or litter removal, or lack of sufficient time between broods, a special effort should be made to rake out and remove all damp or lumpy litter, feathers, and dead chicks from the old litter before adding a topping of fresh litter. As a compromise, litter is sometimes replaced entirely in the hover area, and 1 or 2 inches of new litter put on top of the old litter in other areas. The litter and dirt that are removed should be disposed of away from the houses so as not to blow or be tracked back into them.

After the floor has been thoroughly cleaned and disinfected and before the new litter is added, the ceiling and walls should be swept or blown clean of dust and cobwebs. Hose them down with water at about 300 pounds' pressure. Use a good detergent. A steam jenny is useful because the heat generated may be a valuable supplement to pressure and a disinfectant in eliminating certain diseases and parasites. After the house is dry, spray it with malathion for mites and lice (see p. 56).

To control rats and mice, keep the premises clean, have a rodent-control service use calcium cyanide dust in outdoor rodent burrows, or use anticoagulants, such as warfarin, pival, fumarin, or Diphacinone in suitable baits, or buy a commercially prepared, ready-to-use bait mixture and follow the manufacturer's recommendations. A good bait formula includes—

	Cups
Cornmeal	13
Oatmeal	4
Corn oil	1
Confectioners' sugar	1
Anticoagulant	1

In preparing the house for a new brood, check all wire screens to be sure wild birds cannot enter. Close all openings with ¾-inch mesh wire. Remove tall grass and weeds for at least 30 feet from the house to prevent cutting off ventilation and as a fire precaution. Clean out all ditches not only to give good drainage from the house but to eliminate breeding places for mosquitoes and other insects. The roads and roofs should be put in good repair, especially in the fall. Check the curtains or frames for holes and be sure they are in good working order.

Between broods, be sure that each hover is clean and free from dust and dirt, which could cause a fire or an explosion. Infrared hovers should have been cleaned and covered tightly with a plastic bag immediately after being discontinued. A portable air compressor to give about 100 pounds' pressure has many uses in the cleaning process and can be purchased for as little as $25. Check all thermostats, fuel lines, and hoisting ropes not only to assure satisfactory operation but to prevent accidents and fire. All water valves should be in good working order. All light bulbs should be checked and cleaned.

It is desirable to have the house empty for at least a week after it is clean and ready for occupancy. Before the chicks arrive, all the workable parts of the brooder should have been checked and the brooder should be in operation and adjusted to the desired temperature. The feeder lids and gallon water fountains should be in place, as well as the chick guards if they are used. All fountains and feeders should usually be rinsed after disinfecting.

Lights

Probably no management practice varies more than the lighting schedules for broilers. Lights are used to prevent chickens from piling or stampeding when scared. Enough light should be provided to attract the chicks to the source of heat. With most gas-burning hovers, sufficient light is supplied so that no additional light is needed. When the source of heat does not suffice, an attraction light, or small light under the hover, should be provided 24 hours daily for about 2 weeks. Properly spaced 15- or 25-watt bulbs are usually adequate.

Lights are used after the chicks are 2 weeks of age to prevent piling and to allow more time to eat. In the fall and winter, days are too short. When broilers are uncomfortably hot, they do not eat, especially in the middle of the day. The use of lights at night, when it is cooler, often results in materially increasing feed intake.

For general use, it is suggested that natural light be supplemented with all-night lights from the third week to the time of marketing. To avoid piling in case of power failures, it is desirable to allow at least 1 hour of darkness in every 24-hour period. Too intense light may cause stress. An intensity of 1 foot-candle at feeder height is recommended for maximum gains. As broilers grow, the light intensity can be reduced to as little as 0.1 foot-candle and still be satisfactory. In houses 40 feet wide, two rows of 100-watt bulbs 10 feet from the sides, 10 feet on center, and at an 8-foot height will prove adequate, if bulbs are kept clean or reflectors are used. The rule-of-thumb practice is one-fourth watt per square foot of floor space. The color or kind (incandescent versus fluorescent) of light does not affect growth. Blue lights may be used when catching birds and red lights in case of cannibalism.

Another program is to allow 2 foot-candles at feeder height from 2 to 4 weeks, 1.5 foot-candles from 4 to 6 weeks, and 1 foot-candle from 6 weeks to market. Light intensity can be altered by changing the size of the bulbs.

Floor Space

The amount of floor space allowed varies from 0.8 to 1 square foot per chick. The actual amount will depend on such factors as the weight at which the broilers are to be sold, the prevailing price of broilers, the extent to which the environment is controlled, and the season of the year.

Crowding broilers will usually result in more culls, a lower average body weight, poorer feed conversion, more cannibalism and feather picking, decreased market value, and higher mortality.

For birds to be marketed at about 3 to 3¾ pounds, usually allow 1 square foot of floor space in the summer. The rest of the year and in fan-ventilated insulated houses, the allowance is 0.8 square foot. For broilers to be marketed at 4 pounds and over, allow 1 square foot normally and 1¼ square feet in hot weather.

Size of Units

Houses currently being built in the major broiler-producing areas will have a minimum capacity of 7,200 (24 by 300 feet) and will usually approximate 12,000 (40 by 300 feet) birds. The house may not be divided into pens or have as few as 1,200 birds per pen. Generally the smaller the pen, the better the results one can expect. Factors to consider are the relative convenience of managing the birds, the cost of the partitions, and the value of partitions in restricting disease.

Waterers and Watering Space

Clean water at about 55° F. should be available. Thoroughly cleaned, disinfected, and rinsed gallon fountains with wide-based, spillproof plastic bases should be provided at the rate of 10 per 1,000 chicks. Some hanging waterers (fig. 11) can be lowered so that the chicks have early access to them. **When all the chickens are drinking from the automatic waterers, the gallon fountains should be removed,** cleaned, and preferably stored in a special dustproof place. Fountains should not be used after 3 weeks, and usually they are discontinued after about 10 days. Some automatic waterers can be used successfully from the start.

It is a good investment to have automatic waterers. If the 8-foot automatic hanging waterer is used, at least one-half linear inch per bird is usually allowed or three waterers per 1,000 birds. One additional waterer per 1,000 should be added when the temperature is 90° F. or above. The birds should not have to go more than 10 feet to get water at any time.

Waterers should be washed daily. The use of a 5-gallon bucket with a 4-inch V cut in the top of one side is suggested. One end of the trough can be set in it as the trough is brushed or mopped clean. The lip of the waterers, too, should be adjusted weekly to the back level of the average bird in the house for optimum water intake and less spill. Keep debris out of the waterers. More waste feed has been recovered from V-shaped troughs than from the deeper types. The valves on the waterers should be checked daily and between each brood.

It is often difficult to maintain a constant water supply in cold weather. Electric heating cable can be used to protect pipes from freezing. The cable can also be used in trough-type waterers. The water is usually maintained at not less than 40° F. The minimum temperature will vary depending on the location of the piping, the construction of the house, and the supply of heat from the birds and other sources.

The type of electric cable used for pipes in broiler houses has a heating capacity of 5 watts per foot. The length of the cable required depends on the total length of piping and the number of watts per foot of pipe required. Anyone not familiar with electrical installations of this kind should consult a competent electrician or power-company representative.

Chick Guards and Other Management Practices

In cold weather the use of a 12-inch corrugated paper circle 2 feet outside the edge of the gas, oil, or electric hover will help prevent drafts on young chicks. In hot-water brooding, guards are usually placed 3 feet from the outside edge of the hover. Sometimes removable 1-foot boards can be used in place of cardboard. For infrared brooding, these are sometimes inserted in cleats on the posts along one side of the house. When room temperatures are 70° F. or higher, either the guards are not used at all, or corrugated board is replaced by ¾- or 1-inch mesh wire and the guards are removed at the end of 4 days. Guards normally can be removed at the end of a week.

Although the first 10 days are extremely important in the life of the chick, the first 2 days are critical. Fill the fountains the night before to remove the chill from the water. Carefully place the fountains and feeders around the hover so that they are easily accessible to the chicks. **Know the temperature under the hover** and adjust it to outside weather. For the correct temperatures, see page 18. Normally the temperature should be 95° F. at chick level the first 2 days. Do not run some hovers at 85° and others at 110°. Except in a single-unit operation, the action of the chicks is not a sufficiently reliable guide to temperature. A desirable room temperature is 70°. Try to maintain at least 60°, then chicks that wander from the hover are less likely to be chilled. Ventilate the house to keep the air fresh, but avoid drafts. Discourage visitors to the house, especially at this time.

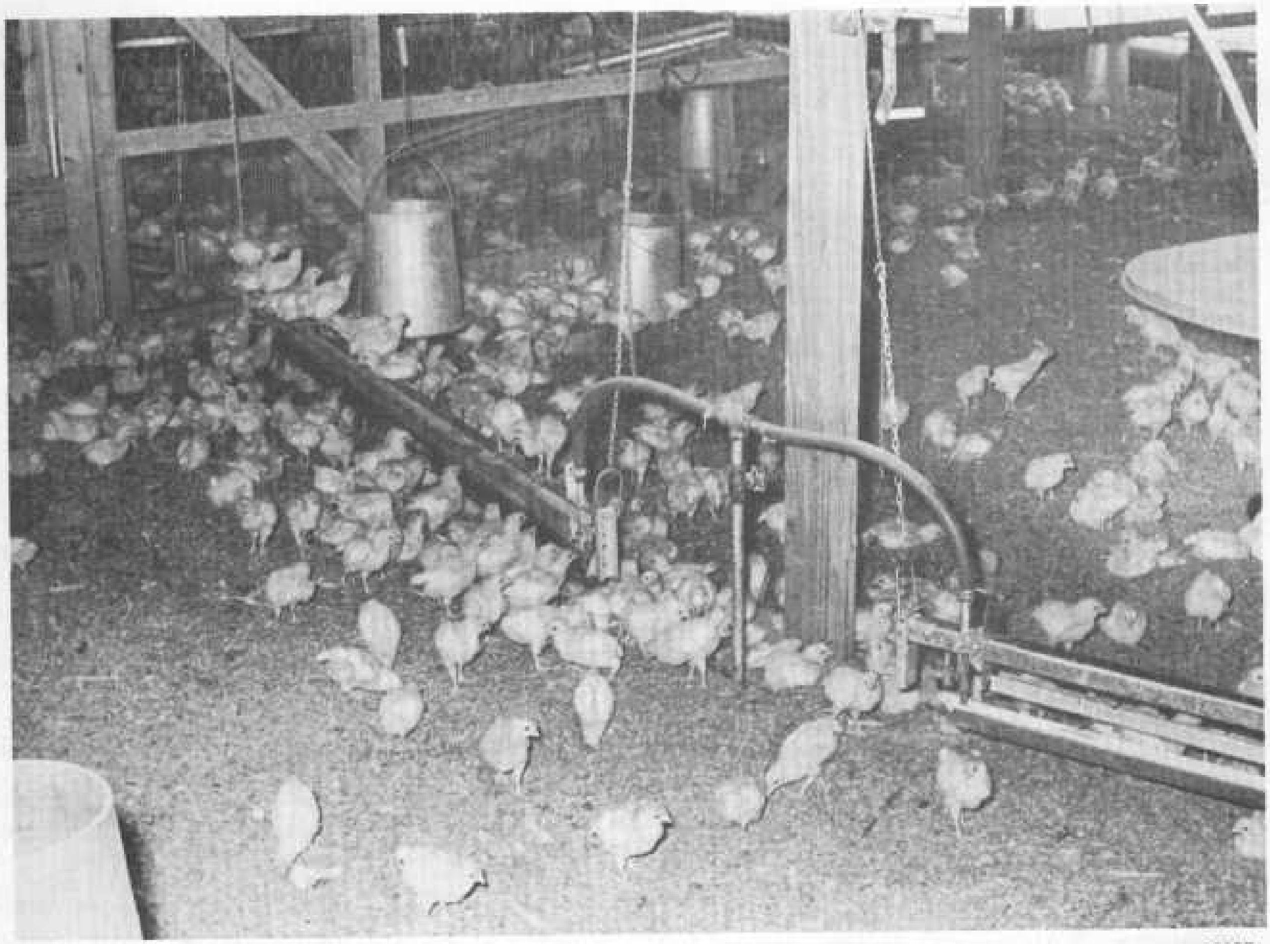

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FIGURE 11.—Hanging waterers lowered so chicks have early access to them.

Debeaking

Careful debeaking of birds fed crumbles and pellets will materially improve the percentage of grade A birds marketed. There are many different methods of debeaking, all of which seem to be effective, including notching so that the end of the beak drops off. Usually one-third of the upper beak between the tip and the nostril of the day-old chick is removed. If debeaking is too severe, growth is retarded and some mortality may result. Mash feed wastage is usually less with debeaked chicks.

Feeders and Feeder Space

New, cut-down chick boxes or box lids are generally used at first for feeding the chicks, allowing one feeder lid per 100 chicks. These feeders allow the chicks to find the feed easily. The feeders should be placed in the immediate hover area. They may be removed as soon as the chicks are eating from the regular feeders in from 5 to 10 days. When hanging feeders are used, the bottom pans (fig. 10) are often utilized in addition to some lids.

Several factors should be considered when equipping a house with feeders. The two most important are the amount of labor required and the cost of the equipment. However, in individual situations such factors as managerial, physical, and mechanical ability may be equally important. Much depends on the capabilities of the person taking care of the birds. The cost of the trough feeders per 1,000 birds is usually the lowest, but the labor cost is generally much higher in commercial houses of over 6,000 birds.

It has been shown that with all types of feeders less wastage occurs with pellets than with mash.

The mechanical poultry feeder is probably the most important labor-saving device the poultryman has. Without a mechanical feeder, but with automatic waterers, one man will spend full time looking after a flock of 6,000 broilers. With automatic waterers and a mechanical feeder, the same man can look after 15,000 to 20,000 birds. If extra help is available during the first week, a good grower can attend to 50,000 broilers.

A bulk feed bin holding several tons of feed, which can be serviced outside the house, is usually located in the center of the house. The mechanical feeder has a hopper that is fed from the storage bin. The feed is distributed in a continuous trough through the house by a motor-driven drag chain or shaker, by a closed conveyor system, or by hanging feeders that move to a hopper for filling. When sacked feed is used, it is stored near the hopper and put in by hand. Most mechanical feeders are controlled by a time switch, but a feed-consumption controlling device is sometimes used to actuate the motor drive.

The original cost of mechanical feeders is usually higher than for hanging or trough feeders. In modern broiler production, mechanical feeders often are economically justified. The recommendation of the manufacturer should be followed as to feeding space. It will usually approximate 10 to 12 broilers per linear foot of feeding space.

As a rule of thumb, installation of a mechancal feeder or feeders is worthwhile if the investment is no more than five times the labor saved in a year. If the use of mechanical feeders will save an hour a day at a dollar an hour, the grower will save $365 annually; he can afford $1,825 for equipment. With labor at $1 per hour, 13 flocks will often pay the replacement cost of mechanical feeders in flocks of 10,000 or more. The cost of the mechanical feeder should be depreciated annually at 10 percent, interest should be charged at 6 percent, and 3 percent should be allowed for repairs. The bulk storage should be depreciated at 5 percent, interest charged at 6 percent, and 1 or 2 percent allowed for repairs, depending on its construction.

Operating the mechanical feeder will require 15 kilowatt-hours per 1,000 broilers. The labor requirement per 1,000 broilers is reduced more by mechanical feeders as compared to trough or tube feeders when a larger number of birds are involved.

With mechanical feeders, the grower can observe the birds more frequently. It is usually difficult to justify a mechanical feeder for fewer than 6,000 birds unless the age or physical condition of the caretaker will enable him to benefit by it or unless suitable labor is difficult to get when needed. Some of the disadvantages of mechanical feeders may be greater waste of feed, greater difficulty in adjusting to proper height, more tendency for growers to neglect birds, and inability of growers to maintain the equipment properly.

The hanging tube-type feeders (fig. 9) are sometimes preferred to the mechanical feeder, because they require the grower to spend more time with the birds, they are easier to adjust, and may cause less downgrading. When these hanging feeders are used, fifteen 15-inch diameter tube feeders, holding about 30 pounds of feed, are suggested per 1,000 broilers. Probably fewer feeders will be needed for a high- than a low-energy ration, because the feed intake normally is less. With some low-energy rations, twice as many may be needed. Usually more downgrading occurs when more feeders are in the pen.

With labor at $1 per hour, 10 flocks will often pay the cost of replacing trough feeders with hanging feeders in flocks of 10,000 or more. Hanging feeders are preferred to trough feeders because they do the entire job, are easier to adjust, if properly adjusted cannot be overfilled, need not be filled so often, and cause less injury to the birds. One of the principal disadvantages is the tendency in most feeders for high-fat feeds to stick to the sides and hang up. The many ropes or wires supporting tube feeders are somewhat objectionable.

The use of trough feeders is usually limited to flocks of 5,000 birds or fewer, to situations where they are already installed, and where labor cost is not important. Usually more feed is wasted with trough feeders, and they take up more floor space. Their principal advantages are absence of hanging ropes, no hang up of feed, and the grower's spending more time with the birds. When these feeders are used, a 4-foot chick trough feeder is generally preferred, allowing 10 per 1,000 chicks started. At 3 weeks, a change is made to the 5-foot broiler feeder, and 25 of these feeders provide 3 linear inches of space per bird.

Much feed wastage is avoided by not filling feeders more than half full and feeding three times per day. The labor of feeding at this rate can be justified in improved conversion. The space allowance is undoubtedly affected in all types of feeders by the energy content of the feed as well as the form in which it is fed. Less hopper space is needed with high- than low-energy rations and with pellets or crumbles as compared with mash. Feeders should have a lip to prevent "billing" and wasting of the feed. Usually the lip of the feeders of all types is adjusted weekly to the back height of the average bird in the pen or house. All feed troughs should be kept level to assure optimum feed intake with minimum feed wastage. Some growers hang their feed troughs. When either tube or trough feeders are used, bulk storage bins are usually placed to serve two pens.

MANAGEMENT PRACTICES

Good management practices are summarized on the inside front cover and a management guide is given on the inside back cover of this handbook.

Size of Operation

In general, a person will not undertake a broiler enterprise unless it will provide at least a quarter of his income. Most growers have at least 5,000 broilers per lot. So many other factors are involved that apparently little or no relationship in general exists between the size of the enterprise and the rate of growth or feed efficiency obtained. A small broiler raiser may be able to do as well on a per bird basis as a large producer. However, as the number of birds increases per grower or per building, the standard of housing, equipment, and general management needs to be higher for economical results.

The number of birds cared for by a family unit tends to increase on either a full- or a part-time basis. The amount of time given to the enterprise is an important consideration. The amount of available finances may be a limiting factor. The number of broilers a family unit can handle satisfactorily will depend principally on the ability of the individuals, the size and arrangement of the house or houses, and the labor-saving equipment, especially in the feeding and watering operations. For further information, see page 7.

Labor Efficiency

The two best assurances of good management are a congenial working relationship between the growers and the servicemen and the selection of growers who either stay home when they have chickens or have efficient assistance. Considerable variation exists between farms in the amount of capital, in other resources, and especially in the managerial capabilities of the grower. There can be no best plan covering labor, housing, and equipment for all farms.

When considering any plan, it is necessary to know the least cost of doing a particular job. The cost of labor on a particular farm and the availability of money are extremely important. If labor is excessive on the enterprise, it is doubtful whether much capital outlay in labor-saving equipment can be justified. On the other hand, managerial problems can often be minimized by reducing drudgery.

Stress Factors

Stresses cause physiological and biochemical reactions, which often depress growth rate or feed conversion. Combined or severe stresses may result in culls or deaths. Most stresses can be avoided by good management and nutrition. Environmental stresses include too high, too low, or sudden changes in temperature; too high humidity at high temperatures; too many chicks per brooder; too little floor space; faulty ventilation; insufficient feeding or watering space; improper debeaking; disease outbreaks; loud noises or other things that frighten birds; and sudden changes in personnel and in management practices.

Common nutritional stresses include all nutritional deficiencies, mineral imbalances, certain hormones, most drugs, and certain ingredients at higher than optimal levels. Chickens may react to mild stresses in such a way that no effect is observable. However, chickens subjected to both environmental stress and nutritional deficiencies are more liable to succumb to disease. Under stress, requirements are probably increased for certain amino acids, vitamin A, and unidentified growth factors. Nutritional requirements for practical broiler formulas allow for these increased needs.

Grower Supervision

Growers may be supervised by the feed dealer or by a serviceman. The duties of the serviceman vary with almost every situation. Management policies differ in the amount of discretion allowed the serviceman and that allowed the grower. A grower who has proven his ability is often given much greater leeway than one who has not done so. The best growers are not necessarily with the company offering the greatest money return, although there is usually no better incentive than the financial return. If a company and the serviceman are consistently fair to their growers, maintain good relationships with them, and have prestige in the industry, they *may* get *some* of the best growers, with what a grower may consider a less satisfactory contract.

In general, the serviceman provides the personal contact between the company and the grower and in so doing gives a measure of protection to the financial risk the company has in the contract. He should provide the grower with detailed information on approved practices of management and disease prevention and control. He should be specific and clear in his instructions. He should give priority to grower communications, listen to their complaints, exchange ideas with them, and weigh their suggestions. When justified, the growers should be commended. Probably nothing is more important in obtaining good results than to have good relationships between the serviceman and the grower. A management program must be simple, definite, and consistent.

The principal responsibility of the serviceman is usually to visit the broiler growers. He generally visits each grower once a week. Fewer routine calls are made on the best growers, and he makes special visits when called. The broilers and the broiler house are checked and orders for feed taken. When the broilers are about ready, their marketing is discussed.

If a serviceman does not have enough growers to occupy all his time, and sometimes when he does have, he often is called on to assist the grower in vaccinating his chickens, to deliver chicks and feed, to help load and haul broilers to market, or to assist with office records.

Most servicemen are paid a straight salary. As an additional incentive, a bonus system may be desirable. For example, a monthly check could be given to the serviceman of the group of growers having the lowest cost of production. Alternatively, a serviceman could be given increased remuneration when his growers exceed an agreed average point spread or "production efficiency" index.

General Sanitation

Security Management

Security management is a method of disease control. The objective of a preventive program is to stop the mechanical spread of disease organisms. Most diseases cannot occur without such disease-producing organisms as bacteria, viruses, and parasites. Their spread between and within farms must be prevented. A security management program is necessary because disease agents can enter a flock from so many sources. Disease-producing organisms can survive away from the bird for at least a few hours, possibly for days or weeks.

(1) Sanitation should start with clean eggs. Do not store clean eggs in dirty flats nor in used nondisinfected cases. Chicks should be delivered from a clean hatchery, which is free of pullorum and fowl typhoid, by attendants wearing clean outer clothing and plastic boots. Do not ship chicks by common carrier, such as train or bus. Use new or clean disinfected boxes to transport them.

(2) Isolate chicks from older birds and visitors, especially during the first 4 weeks. A separate caretaker is desirable. Keep houses locked at all times, even when the caretaker is inside. Exclude children, dogs, cats, and wild birds from poultry houses and follow a fly-control program.

(3) Do not allow visitors in the same room with the birds. If observers are necessary, they should wear clean rubber boots, which have been disinfected with quaternary ammonium compound, when entering and leaving the premises. Plastic boots in addition are desirable. If the birds are to be handled, clean coveralls should be worn. The poultryman should himself not be a visitor to other flocks. (Servicemen should start out with clean outer clothes each morning. They should first visit flocks under 4 weeks of age with no apparent disease.)

(4) When birds are sold, remove the entire group from the farm. Birds of more than one age should not be on the same farm at the same time. No stray or yard bird should be on the premises.

(5) Normally the brooder house should be thoroughly cleaned and disinfected between broods. It should remain empty and clean for at least a week. The brooder house should be well ventilated. It is desirable that it be insulated and, when economically feasible, have a concrete floor.

(6) Houses and equipment should be thoroughly cleaned. Blow out or brush down the dust, spray the house, and disinfect it at 300 pounds' pressure. Rinse equipment with clean water after disinfection. When practical to do so, expose equipment to the sun. After the equipment is returned to the house and clean litter added, lock all doors. Place a pan of disinfectant at each door to be used by the attendant. Anyone who must enter should be required to dip his shoes in the pan.

(7) The litter should be free from mold, have a minimum of fine material, and be kept dry but not dusty.

(8) The feed should not be delivered into the broiler house. The feed man should never have to enter the house.

(9) In a disease outbreak, obtain a prompt, accurate diagnosis from a professional source, and start the proper treatment at once.

(10) Have and use a properly constructed, conveniently located disposal pit or incinerator of adequate size.

If properly followed, the security management program should considerably reduce disease losses as well as reduce the drug bill.

Disinfection

The producer should know what proper cleaning is, why it is necessary, and how to do it. Most disease germs can be killed only by disinfection after thorough cleaning. The virus diseases are best controlled by strict cleanliness. Effective cleaning begins with the removal of litter and manure. The cleaning process includes scrubbing with brushes until surfaces are visibly clean, using a good detergent, flushing with clean water, and then applying an approved disinfectant. One advantage of a cement floor is that lye (caustic soda) can be used effectively. Since it corrodes metals, lye cannot be used as a general cleaner. A 2-percent lye solution should be used only when the temperature is above 32° F. Because it irritates the skin, one needs to be cautious in its use. Lye can be used on a dirt floor after it has been swept clean.

Quaternary ammonium compounds should be used in concentrations of 200 p.p.m. (1:5,000) and applied only to properly cleaned surfaces. Hard waters slow their effectiveness. These compounds can be used for flushing floors and walls and for disinfecting equipment. They are effective against most disease-producing bacteria and viruses.

The cresylic compounds are good disinfectants for general use. If a preparation has a phenol coefficient of 5, it is five times more germicidal than phenol. It would be used in a 1-percent concentration, because the recommended dilution of phenol is 5 percent. The cresylic compounds can be used for disinfections for nearly all bacterial and virus diseases.

The presence of organic matter (dirt and manure) in the disinfecting solution or on the surfaces to be disinfected may prevent the solution from destroying disease organisms so that no disinfection results.

Parasite Control

After the house has been disinfected, malathion can be used to control lice, mites, flies, and other external parasites (see p. 56).

To control tapeworms, attack them at the developing stage in the intermediate host. This is best done by removing manure or litter, which serves as a breeding place for beetles, ants, flies, earthworms, slugs, or snails—the intermediate hosts of the tapeworms. When a tapeworm problem exists, the change of litter after each brood is usually essential.

The large intestinal roundworm, *Ascaridia galli*, has no intermediate hosts. The eggs are hard to kill. Preventive measures include general sanitation.

CHICKEN-MEAT PRODUCTION

Cornish Game Hen

Cornish game hens, otherwise known as Rock Cornish game hens, or baby broilers, are young immature chickens usually produced in about 5 to 7 weeks. They range from 1½ pounds to 2 pounds live weight when marketed. They weigh about 16 to 28 ounces oven-ready. Although their production is a specialized phase of the poultry industry, it is similar to regular broiler production in many ways. With few exceptions, the usual methods of brooding and management are followed. Only one-half square foot of floor space is provided per bird. Most of the baby broilers are raised under contracts similar to those used for heavier broilers.

The ration used is high in protein (24–25 percent) and in energy (1,450 to 1,500 metabolizable calories). A high calorie broiler starter ration should serve the purpose. It should give the desired weight and feed conversion of 2. The vaccination and disease-prevention program will depend on local conditions and needs.

Most processors want birds to average 1½ pounds live weight and 16 to 17 ounces when ready for the oven. Other processors pay a bonus for birds weighing 2 pounds and want an eviscerated weight up to 24 ounces. The age for marketing cockerels is 4½ to 5 weeks. The last of the pullets go at 6 weeks. Overweight birds are grown out as broilers. The dressing percent (New York dressed) will be about 88 for 2-pound live-weight Cornish hens. The eviscerated weight will be about 68 percent of the live weight. As a percentage of live weight the following can be expected: Breast meat 14 or 15, head 2 to 3.5, feet and shanks 4 to 4.5, giblets 5.5, and viscera 11 to 12. The total edible meat will be about 46 percent with males and 47.5 with females of eviscerated weight.

The killing and processing methods are similar to those for heavier chickens. A semiscald at 126° to 129° F. is usual. The birds are then iced if to be sold fresh. Because of the variable demand for this specialty product, quick freezing is customary, using transparent plastic bags. It must be kept in mind that owing to the weight at which these baby broilers are sold, the cost per pound is much higher for the baby chick and for processing. Overhead is less because more batches can be raised per year.

Broilers and Small Roasters

The average housewife prefers a dressed or cut-up broiler or fryer that weighs 2 to 2½ pounds, rather than a heavier one. Some of the eastern broiler areas market a bird that has a live weight of 4 pounds at between 9 and 10 weeks of age. If carried to 11 weeks, the males will weigh 5 pounds and the females about 4 pounds. The feed conversion is about one-fourth pound better for a 3½- than for a 4½-pound broiler. The extra feed cost to 11 weeks is offset, at least in part, by the lower cost per pound for the chick and for brooding. As one less lot can be raised per year with the larger broiler, the overhead cost is greater for it.

With large broilers or small roasters, in addition to the general problem of consumer demand, the increase in breast blisters (p. 28) and in mortality has to be considered. The greater mortality can be minimized by good management practices. For information on feather picking and cannibalism, see page 56.

The heavy broiler is ideal for roasting. Roast chicken is tender, tasty, and an ideal size for the small family. It would give a greater return to the producer if grown in quantity for a prearranged market.

Large Roasters and Capons

Large roasters and capons may be raised either in confinement or on range. The tendency is to raise them in confinement; pole-type houses are extensively used. Provide one-half square foot of space per bird until birds are 6 weeks old, 1 square foot to 10 weeks, 2 square feet to 16 weeks, and 3 square feet to market. Roasters and capons are brooded, fed, and managed as broilers to 6 weeks of age.

A capon is a castrated male chicken. After this surgical operation, the bird fattens more readily and produces more tender meat. Capons sell for a higher price per pound than broilers or roasters, because they require more labor and cost more to produce. They do not use feed as efficiently as lightweight birds.

Most poultrymen caponize cockerels that are 3 to 5 weeks old. The operation is of little value after chickens are 2 months old. After the operation, put capons in clean quarters, separated from other chickens for 2 or 3 days. Capons do not need special care after they recover from the initial shock of the operation. For directions on how to caponize, see the U.S. Department of Agriculture Leaflet 490, Caponizing Chickens, or consult your county agent or a poultry specialist.

A compound, dienestrol diacetate, sometimes is added to special feeds to produce a feminizing effect on male chickens. This may result in fattening and tenderizing of rapidly growing birds. If you use this compound, follow the directions of the manufacturer.

Give roasters and capons the kind and amount of feed recommended for broilers during the first 6 weeks. After changing to finishing mash, supply cracked corn to roasters and capons in the afternoon. Gradually increase the grain until birds are getting equal amounts of corn, mash, and pellets at 12 weeks of age. For roasters, increase the corn in the diet to 50 percent after the 15th week. Continue to supply grit as long as birds are fed whole grain.

The fixed or overhead costs of producing roasters and capons are higher than for broilers, as more lots of broilers can be produced within a year. The chick cost per pound will be less for the heavier birds. The cost of producing male broilers is less than for female broilers, capons, and roasters, including those few produced by feeding dienestrol diacetate.

If capons are kept beyond 6 months, their rate of growth is superior to nontreated males of the same age, because they then put on weight much more readily than do roasters. As birds get older, their feed efficiency is poorer and mortality can be higher. This must be considered in figuring cost of production. As caponizing males sets back their growth rate slightly, there is no great difference in the comparative growth rates of capons and roasters to 6 months of age. Roasters fed with dienestrol diacetate are usually marketed when 14 weeks of age. Time of marketing will be conditioned by price and consumer preference for roasters and capons.

Breast Blisters (Sternal Bursitis)

With roasters and capons, special attention needs to be paid to the prevention of breast blisters. Many carcasses are downgraded because of them. Some strains of birds seem more susceptible to this condition, possibly because of the breast angle or the feather coverage of the breast. For information on a causative agent, see page 54.

Breast blisters occur more in males than in females and more in large than in small birds. Rate of growth seems to be involved. The most important preventive measure is to have ample floor space and deep, dry, clean litter. Conditions that seem to irritate the keel bone and contribute to the trouble are wet or caked litter and roosting places with sharp edges, such as waterers or feeders.

Marketing

In general, roasters and capons are marketed in a similar way to broilers. As they are specialty products, like baby broilers, care must be taken to have an assured market. Losses can mount rapidly with a glutted market. Birds treated with dienestrol diacetate and similar materials are usually sent to market live weight at 5 to 6 pounds. Their market quality is usually superior to that of untreated males of the same age, but is not equal to that of capons. The principal demand for capons is for large birds, 5 to 9 pounds, ready-to-cook weight. Roasters usually average 3½ to 6 pounds. The superior market quality of capons warrants a higher price for them.

FEEDS AND FEEDING METHODS

Most broiler feeds are produced by a feed-manufacturing company, the feed-mixing unit of an integrated operation, or a large independent producer. The processed feeds are usually mixed in a centrally located mill and are delivered in bulk by truck to the broiler farms. It is not generally economical for the individual grower with 10,000 to 50,000 broilers to do his own mixing on the farm.[1]

Importance of a Good Broiler Ration

Any poultry meat-production enterprise must use a feeding program that will give economical results if the operation is to survive. Usually the best broiler feeding program gives the highest net return. With it, the broilers grow fast, use their feed efficiently, have the desired finish and a high livability, and the feed cost per pound is low. The finish may include plumpness, bright-yellow pigmentation, and good feathering. It is not always possible to get more money per pound for exceptional quality in broilers. Yet a reduction in cost that gives poor broiler quality usually is not justified. As feed costs constitute about 62 percent of the *total* cost of producing broilers, including contract payments, it is important to know what constitutes a good economical ration.

Factors To Consider in a Broiler Ration

Rapid growth in broilers is important, because with increased age and weight more feed is required to produce a pound of meat. By marketing as soon as the desired weight is reached, feed and labor are saved and mortality risk is reduced. However, when the processor will accept larger broilers, when prices are good, and when feed is cheap, larger birds may be more profitable because there are more pounds over which to spread the chick and the overhead costs.

Efficient feed conversion is an important consideration. It may be expressed as the pounds of feed required to produce a pound of live broiler or the pounds of live broiler per 100 pounds of feed (see table 1). If a broiler consumes 8 pounds of feed and weighs 3.33 pounds when marketed, the feed conversion is 2.4 (8÷3.33), and the pounds of meat per 100 pounds of feed are 41.67 (table 1). With a feed conversion of 2.4 pounds, assuming a feed cost of $4.50 per hundredweight, the feed cost per pound of broiler will be 10.8 cents (table 2). If the feed conversion goes up to 2.5, the feed cost per pound goes up 0.45 cent to 11.25 cents, as shown in table 2. On the other hand, if the feed conversion goes down to 2.2 and the price goes up 25 cents per 100 pounds to $4.75, the feed cost per pound goes down to 10.45 cents.

Note that at 2.4 pounds' feed conversion, the change in the cost of 25 cents per hundredweight of ration makes a difference of 0.6 cent in feed cost per pound—a little more than a half cent per pound. As is to be expected, the improvement in feed conversion is of increasing importance as feed prices increase. A feed costing $4.50 would have to have a feed conversion of 2.2 to give about the same feed cost per pound (9.9 cents) as a $4 per hundredweight feed giving a 2.5 pounds' feed conversion (10 cents) (see table 2). However, higher cost feeds should give a greater average body weight as well as improved feed conversion at market age.

Feed cost is approximately 71 percent of the total cost of producing broilers *without contract payments*. The cost of producing a pound of broiler can be roughly calculated by multiplying the feed cost per pound in table 2 by factor 1.41. As an example, if the feed cost per pound is 8.4 cents, the total cost is 11.84 cents. If contract payments are made, the factor becomes 1.60 (feed cost estimated at 62.4 percent of total cost *including contract payments*). The total cost, including contract payments, becomes 13.6 cents per pound.

Point spread usually is a more satisfactory criterion of the worth of a feed than feed cost per pound. The reason is that it takes rate of growth into consideration. Point spread is the weight in pounds times 100 minus the feed conversion times 100. For example, if the average weight is 3.33 pounds, the weight factor is 333. If the feed conversion is 2.40, the feed conversion factor is 240 and the point spread is 333 minus 240, or 93. Its usefulness is limited because it becomes relatively greater as the broiler gets older.

Income over feed cost per broiler is affected by quality of bird, growth, and feed conversion. The income is obtained by multiplying the weight, 3.33 pounds, by the selling price. If it is assumed that the average weight is 3.33 pounds and the feed cost is $4.50 per hundred pounds, the feed cost per broiler is obtained by multiplying the weight, 3.33, by the feed conversion by the assumed feed cost of $4.50. The difference is the income over feed cost. For example, at 13 cents per pound, the 3.33-pound broiler gives an income of 43.29 cents (3.33×13). If there is a 50-point spread, the feed conversion is 2.83, and 3.33 times 2.83 equals 9.42 pounds of feed per broiler. At $4.50 per hundredweight, the feed cost per bird is 42.39 cents (9.42×4.50). The income over feed cost per broiler is 0.90 cent (43.29—42.39). As would be expected, the income increases with the selling price—3.33 cents per bird for each cent increase in selling price.

Without contract payments, feed approximates

[1] For more detailed information, refer to the publication Drugs; Current Good Manufacturing Practice in Manufacture, Processing, Packing, or Holding, obtainable from the Office of Public Information, Food and Drug Administration, 200 C St. SW., Washington, D.C. 20204.

TABLE 1.—*Effect of feed conversion on income*

Feed conversion (pounds of feed per pound of live broiler)	Weight of broiler per 100 pounds of feed	Added weight of broiler per 100 pounds of feed	Value of extra broiler weight per 100 pounds of feed at indicated live-weight selling price per pound						
			$0.16	$0.15	$0.14	$0.13	$0.12	$0.11	$0.10
	Pounds	*Pounds*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
2.8	35.71								
2.7	37.04	1.33	21.28	19.95	18.62	17.29	15.96	14.63	13.30
2.6	38.46	1.42	22.72	21.30	19.88	18.46	17.04	15.62	14.20
2.5	40.00	1.54	24.64	23.10	21.56	20.02	18.48	16.94	15.40
2.4	41.67	1.67	26.72	25.05	23.38	21.71	20.04	18.37	16.70
2.3	43.48	1.81	28.96	27.15	25.34	23.53	21.72	19.91	18.10
2.2	45.45	1.97	31.52	29.55	27.58	25.61	23.64	21.67	19.70
2.1	47.62	2.17	34.72	32.55	30.38	28.21	26.04	23.87	21.70
2.0	50.00	2.38	38.08	35.70	33.32	30.94	28.56	26.18	23.80

TABLE 2.—*Feed cost of producing a pound of live broiler* [1]

Feed conversion (pounds of feed per pound of live broiler) (*a*)	Cost of feed per pound of live broiler (*c*) at indicated cost of feed per 100 pounds (*b*)										
	$5.50	$5.25	$5.00	$4.75	$4.50	$4.25	$4.00	$3.75	$3.50	$3.25	$3.00
	Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
2.8	15.40	14.70	14.00	13.30	12.60	11.90	11.20	10.50	9.80	9.10	8.40
2.7	14.85	14.18	13.50	12.83	12.15	11.48	10.80	10.13	9.45	8.78	8.10
2.6	14.30	13.65	13.00	12.35	11.70	11.05	10.40	9.75	9.10	8.45	7.80
2.5	13.75	13.13	12.50	11.88	11.25	10.63	10.00	9.38	8.75	8.13	7.50
2.4	13.20	12.60	12.00	11.40	10.80	10.20	9.60	9.00	8.40	7.80	7.20
2.3	12.65	12.08	11.50	10.93	10.35	9.78	9.20	8.63	8.05	7.48	6.90
2.2	12.10	11.55	11.00	10.45	9.90	9.35	8.80	8.25	7.70	7.15	6.60
2.1	11.55	11.03	10.50	9.98	9.45	8.93	8.40	7.88	7.35	6.83	6.30
2.0	11.00	10.50	10.00	9.50	9.00	8.50	8.00	7.50	7.00	6.50	6.00

[1] (*a*) × (*b*) = (*c*).

71 percent of the total cost of the broiler. A factor of 1.41 is used to convert feed cost to total cost without contract payments (see table 2). At $4.50 per hundredweight and a feed conversion of 2.2, the feed cost per pound is 9.9 cents (2.2×4.50). The total cost, without contract payments, would be 13.95 cents per pound and the nonfeed costs (chicks, fuel, lights, litter, medicine, and vaccination) would be 29 percent, or 4.05 cents (13.95—9.9) per pound.

With contract payments, the total cost per pound is approximately 1.6 (100÷62.4) times the feed cost per pound, and the nonfeed percent of the total cost is about 37.6. With a feed cost of 9.9 cents per pound, the total cost becomes 15.84 cents and the nonfeed costs 5.95 cents (37.6 percent of 15.84) per pound. The importance of relating average body weight sold and feed conversion with the price paid for the feed is obvious.

To consider mortality as a factor, income over feed cost should be figured on the basis of the number of birds sold.

The broiler-feed ratio is sometimes used as an index of the broiler situation. It is the pounds of feed equal in value to a pound of live broiler. For example, if the price of feed is $4.67 per hundred pounds and the price of broilers is 14 cents, the ratio is 3 (14÷4.67). If the price of feed is $5 per hundred pounds and the price of broilers is 15 cents, the ratio is still 3. The ratio fluctuates widely. It may be as favorable as 5 (average, 1955) or as unfavorable as 2.7 (December 1963).

In table 1, the effect of feed conversion on income can be observed. Of course, the higher the selling price, the greater the value of the extra weight. If feed conversion improves from 2.5 to 2.4, the added weight per 100 pounds of feed is 1.67 pounds. The value at 13 cents per pound is 21.71 cents. If the improvement in feed conversion is from 2.5 to 2.3, the added value, due to the 20 points, is 45.24 cents (21.71+23.53). The feed giving such an improvement in feed conversion would be worth $9.05 (45.24×20; also, 4.33+4.72 in table 3) per ton more. Table 3 can be used as a guide to the comparative value of feeds when their relative feed conversions are known.

TABLE 3.—*Effect of feed conversion on value of feed (see table 1)*

Feed conversion (pounds of feed per pound of live broiler) (*a*)	Weight of broiler per ton of feed (*b*)	Value of broiler produced at indicated live-weight selling price per pound (*c*)							Increase in value of feed per ton as feed conversion improves at indicated live-weight selling price per pound (not cumulative)[1] (*d*)						
		$0.16	$0.15	$0.14	$0.13	$0.12	$0.11	$0.10	$0.16	$0.15	$0.14	$0.13	$0.12	$0.11	$0.10
	Pounds	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
2.8	714.3	114.29	107.15	100.00	92.86	85.72	78.57	71.43	----	----	----	----	----	----	----
2.7	740.7	118.51	111.11	103.70	96.29	88.88	81.48	74.07	4.22	3.96	3.70	3.43	3.16	2.91	2.64
2.6	769.2	123.07	115.38	107.69	100.00	92.30	84.61	76.92	4.56	4.27	3.99	3.71	3.42	3.13	2.85
2.5	800.0	128.00	120.00	112.00	104.00	96.00	88.00	80.00	4.93	4.62	4.31	4.00	3.70	3.39	3.08
2.4	833.3	133.33	125.00	116.66	108.33	100.00	91.66	83.33	5.33	5.00	4.66	4.33	4.00	3.66	3.33
2.3	869.6	139.14	130.44	121.74	113.05	104.35	95.66	86.96	5.81	5.44	5.08	4.72	4.35	4.00	3.63
2.2	909.1	145.46	136.37	127.27	118.18	109.02	100.00	90.91	6.32	5.93	5.53	5.13	4.67	4.34	3.95
2.1	952.4	152.38	142.86	133.34	123.81	114.29	104.76	95.24	6.92	6.49	6.07	5.63	5.27	4.76	4.33
2.0	1,000.0	160.00	150.00	140.00	130.00	120.00	110.00	100.00	7.62	7.14	6.66	6.19	5.71	5.24	4.76

[1] See text.

Feed conversion is given in table 1 as both pounds of feed per pound of broiler and pounds of broiler per 100 pounds of feed. It is often advantageous to convert from one to the other. The effect of feed conversion on the value of the feed is given in table 3. The pounds of broiler (live weight) produced per ton of feed are obtained by dividing 2,000 by the feed conversion. For example, 2,000 divided by 2.8 (*a*) equals 714.3 pounds (*b*). The value of this live weight of broiler at various prices is given in the third column (*c*). For example, 714.3 times 16 cents equals $114.29 (*c*). The increases in the value of the feed due to the improvement in feed conversion are shown in the last column (*d*).

For example, when feed conversion improves from 2.8 to 2.7, the pounds of broiler produced increase from 714.3 to 740.7 and the value at 16 cents per pound increases from $114.29 to $118.51, an increase of $4.22. For the 0.1 pound in feed conversion, the value per ton of feed went up $4.22. Per bag it would be 21.1 cents.

Data in the last column (*d*) are not cumulative. To get the cumulative or aggregate value between efficiencies, add all the increases between them. For example, an improvement in feed conversion from 2.5 to 2.2 at 16 cents would mean an increase in value of feed of $17.46 (5.33+5.81+6.32) per ton without considering the probable increase in average live weight.

Feeding Programs

No feeding program is best for all situations. Sometimes a single complete ration because of its simplicity has proven advantageous, especially in small operations. Broilers should be full fed continuously. Feeding from three-fourths to 1 pound of a prestarter diet usually gets chicks off to a good start. This prestarter is used for 10 to 14 days. It may be the same feed as the starter diet with 100 grams of antibiotic added or it may differ from it in many ways, such as a higher percent of protein, different sources of proteins, and various amounts and kinds of vitamins. The starter is used from the time the prestarter is discontinued to the end of the fifth or sixth week. It usually has a slightly lower protein content than the prestarter and a low level of antibiotics.

The use of a finisher feed at 5 or 6 weeks allows an increase in energy in relation to the protein content of the ration. When desired, increased pigmentation can be obtained by the use of selected ingredients in the finisher. To meet the requirements of laws regarding the withdrawal of some additives just before marketing, a nonmedicated "withdrawal" feed may be fed for a specified period. However, some medicated finishers can be fed to marketing. It is highly undesirable to start chicks on the finisher left over from the previous batch of broilers. The practice is nutritionally unsound. Also, the feed is often moldy.

A prestarter or starter may be fed in mash or crumble form for 2 or 3 weeks. "Starve-outs" are fewer with mash. After 2 or 3 weeks, the starter can be fed in mash, crumble, or pellet form. The earlier the change is made to pellets, the greater the advantage from their use. The finisher feed also can be continued in the same form the starter feed was fed. It is not desirable to change from pellets to mash. Grit can be fed, but it is usually not needed with all mash feeds. When fed, it is generally equal to about 10 percent of the total feed consumed, and the size is varied with the size of the bird.

NUTRIENT REQUIREMENTS

The nutrient requirements of broilers vary with such factors as breed or strain, sex, age, rate of growth, environmental stresses, and disease.

The minimum nutrient requirements[2] per pound of feed for starting chickens from 0 to 8 weeks of age are as follows:

Total protein	percent	20
Vitamins:		
Vitamin A activity	U.S.P. units[1]	910
Vitamin D	I.C.U.[2]	90
Vitamin E		See text.
Vitamin K_1	mg	.24
Thiamine	mg	.8
Riboflavin	mg	1.6
Pantothenic acid	mg	4.5
Niacin	mg	12
Pyridoxine	mg	1.3
Biotin	mg	.04
Choline	mg.[3]	590
Folacin	mg	.54
Vitamin B_{12}	mg	.004
Minerals:		
Calcium	percent	1.0
Phosphorus	do.[4]	.7

[1] May be vitamin A or provitamin A.

[2] See p. 34.

[3] See p. 35.

[4] At least 0.5 percent of total feed of starting chickens should be inorganic phosphorus. All phosphorus of nonplant feed ingredients is considered inorganic. Approximately 30 percent of phosphorus of plant products is nonphytin phosphorus and may be considered as part of inorganic phosphorus required. Part of phosphorus requirement of growing chickens must also be supplied in inorganic form. For birds in these categories, requirement for inorganic phosphorus is lower and not so well defined as for starting chickens.

[2] NATIONAL RESEARCH COUNCIL. NUTRIENT REQUIREMENTS OF POULTRY. Natl. Res. Council Pub. 1345, 28 pp. Washington, D.C. 1966. The values expressed as amount per kilogram of feed, obtained from this publication, were converted into amount per pound of feed for this handbook.

Sodium	do.[5]	.15
Potassium	do	.2
Manganese	mg	25
Iodine	mg	.16
Magnesium	mg	227
Iron	mg	18
Copper	mg	1.8
Zinc	mg	16

[5] Equivalent to 0.37 percent of sodium chloride.

These requirements are adequate for optimum results as well as normal health. When considering the values to be used for practical broiler feeds, the feed formulator should evaluate his own situation and determine margins best suited to it. A guide to nutrient specifications is given on page 46.

Broiler feeds should provide proteins, carbohydrates, fats, minerals, vitamins, and unidentified growth factors in proper balance. Incomplete or unbalanced rations may result in poor growth, inefficient utilization, and nutritional diseases.

In Nutrient Requirements of Poultry,[3] data are given on the daily nutrient requirements and the feed and time required to obtain certain average live weights with heavy breed chickens.

Protein

The broiler depends mainly on protein for building tissue. Prestarter and starter diets should contain 20 to 24 percent of protein. The source of the protein and the energy content of the diet are important considerations in determining the exact percentage. The quantity of certain of the amino acids found in the protein is more important than the total protein quantity in the diet. The various plant and animal proteins differ basically because of these amino acids they contain.

The essential amino acid requirements for the ration of starting chicks based on a protein level of 20 percent and a metabolizable energy level of 1,250 calories per pound are as follows:[3]

Amino acid	*Percent of ration* [1]
Arginine	1.2
Lysine	1.1
Histidine	.4
Methionine	.75
or	
{Methionine	.4
{Cystine	.35
Tryptophan	.2
Glycine [2]	1
Phenylalanine	1.3
or	
{Phenylalanine	.7
{Tyrosine	.6
Leucine	1.4
Isoleucine	.75
Threonine	.7
Valine	.85

[1] These are estimates of requirements and include no margins of safety.

[2] Chick can synthesize glycine, but synthesis does not proceed at rate sufficient for maximum growth.

[3] See footnote 2, p. 32.

It is not advisable to allow any amino acids to exceed very much their actual requirements. To do so may increase the cost of the ration unnecessarily and also may depress growth, due probably to imbalance. Most efficient growth results when the essential amino acids are present in adequate and balanced quantities.

The availability and the amount of amino acids in any protein material are affected by the processing conditions, especially the temperature used and the length of time a meal is exposed to it. Vegetable protein meals that have not been heated excessively during processing are usually the most desirable. However, some meals are underprocessed to the extent that the amino acids are only partially available.

Energy

Energy and the relation of energy to protein and to amino acids are important considerations in broiler feeding. Both productive energy and metabolizable energy determinations are used by feed formulators. Variable values for productive energy are obtained unless a controlled environment and genetically uniform chickens are employed in test procedures. Tables for productive energy values have been used, because more values were available for the various ingredients and for finished feeds. Metabolizable energy values vary with the dry-matter content of the ingredient or ration. As more values are available, greater use is made of the metabolizable energy values in feed formulation.

Carbohydrate and fat serve primarily as sources of energy although protein may also be used for this purpose. Amounts of energy in excess of needs are stored as body fat. Carbohydrate includes nitrogen-free extract and crude fiber. Nitrogen-free extract includes starches and sugars that are readily utilized. Crude fiber is not utilized by the chickens. If good feed efficiency is desired, the fiber content of the ration should be kept low. The grains and their byproducts are the principal sources of carbohydrate.

Fat is present in most feedstuffs. The fat content of the ration can be raised by adding various commercially produced stabilized fats from animal and vegetable sources. The addition of some fats to certain diets increases the rate of growth. Dietary deficiencies of certain unsaturated fatty acids can be overcome by linoleic, but not linolenic, acid. Feed efficiency normally improves as the fat content of a ration is increased.

Vitamins

The gross symptoms often seen in chronic deficiencies of any of several nutritional factors may be similar, such as retarded growth, ruffled plumage, general weakness, loss of appetite, and emaciation. Vitamins are nutritional factors considered necessary for growth and maintenance of health. For the symptoms and lesions of important nutritional deficiency diseases in broilers, see page 51.

The requirements for the needed vitamins are sometimes met by the natural feedstuffs. In some cases, the need for a vitamin requires the addition of a concentrated source or vitamin supplement to the ration, because the natural content is too low or there has been or might be loss due to oxidation.

Most practical broiler formulas do not benefit by adding folacin, biotin, ascorbic acid, vitamin B_6 (pyridoxine), or thiamine.

Vitamin A

Vitamin A is required for the normal functioning of the epithelial tissues of the membranes of all the principal functional tracts of the body. Normal functions, such as growth, development of bones, and resistance to infectious disease, are totally or partially dependent on this vitamin.

The requirements for vitamin A are expressed in U.S.P. units of vitamin A activity per pound of feed. Normally 0.6 μg. of beta-carotene appears to be equivalent to 1 U.S.P. unit of vitamin A. The principal sources of the carotene, or provitamin A, in broiler rations are alfalfa meal, yellow corn, and corn gluten meal. To meet the full requirements, a vitamin A concentrate is often added and especially to rations in which milo or wheat replaces yellow corn and in high fat diets.

When losses may be due to the action of certain minerals, heat during storage, or pelleting, a stabilized product is used or a margin of safety allowed. It is not unusual to include enough vitamin A in the ration to build up and maintain a reserve of vitamin A in the liver. To do this, more vitamin A may be advisable with certain diseases, such as coccidiosis and chronic respiratory disease (CRD), and when birds go off feed. Any deficiency retards growth. An extreme deficiency affects the health of the bird. For symptoms, see page 51.

Vitamin D

The requirements for vitamin D are expressed in international chick units per pound of feed. Chicks effectively use vitamin D_3 from irradiated animal sterol and fish oils, but do not use vitamin D_2 from irradiated ergosterol as efficiently as do mammals. When the minerals in the ration are adequate and balanced, vitamin D is no different in efficiency from fish oils and from irradiated animal sterols.

At one time rickets was a common disease in broilers. It is caused by the nutritional deficiency due to insufficient vitamin D, calcium, or phosphorus, although rarely is a deficiency of the minerals acute enough to bring on the symptoms. The chicks with rickets sit down on their hocks or walk with a stiff-legged gait. They are retarded in growth and appear unthrifty, or without vigor. The breastbone becomes crooked, the rib ends are beaded, and the back and legs are soft and rubbery.

The vitamin D_3 concentrate is usually premixed with yellow cornmeal before it is incorporated in the rest of the ration.

Vitamin E

Vitamin E occurs widely in grains, grain byproducts, and alfalfa meal. It is involved in most of the tissue functions of the chick's body and in the prevention especially of encephalomalacia (crazy chick disease), muscular dystrophy, and exudative diathesis. Most rations have enough vitamin E from natural ingredients, but the content can be materially reduced by oxidative destruction during storage, especially after grinding, and from pelleting.

Vitamin E is not a single chemical entity. It consists of various tocopherols, which vary widely in biological activity. The most active is alpha-tocopherol. One international unit (I.U.) is the biological potency of 1 mg. of dl-alpha-tocopheryl acetate. Another form, also available for feed mixing, is a d-alpha-tocopheryl acetate. One mg. of it is equivalent to 1.36 I.U. of vitamin E.

There seem to be important interrelationships between vitamin E, antioxidants, sulfur amino acids, and selenium in the prevention of vitamin E deficiency diseases (see p. 51). As a margin of safety, 5,000 I.U. of vitamin E per ton are sometimes added to broiler feeds as a supplement.

Vitamin K

Chicks may be hatched with a very low reserve of vitamin K. If fed a deficient ration, they may bleed to death from an injury. Hemorrhages may occur in any part of the chick's body. A lack of vitamin K also delays the clotting time of the blood. Mortality and morbidity of chicks from cecal coccidiosis have been decreased by adding a source of vitamin K to the feed. There is a direct antagonism between sulfa drugs, such as sulfaquinoxaline, and vitamin K. Vitamin K has been beneficial in treating some cases of hemorrhagic disease. For information on hemorrhagic anemia syndrome, see page 52.

Vitamin K_1 occurs naturally in alfalfa meal, dried cereal grasses, soybean meal, and soy oil.

Vitamin K_2 has been isolated from putrefied fishmeal. Vitamin K_3, the synthetic vitamin K, is menadione. Menadione sodium bisulfite, which is extensively used in feeds and water, is an additional compound of menadione. It contains 33 percent of menadione. Added vitamin K sources are used only to meet stress conditions, primarily due to drugs and diseases.

Riboflavin

Curled-toe paralysis is the characteristic symptom of riboflavin deficiency. Other symptoms are retarded growth and diarrhea. In nutritional paralysis, the chicks suddenly start walking on their hocks with the toes curled inward. As they are otherwise healthy, they respond rapidly to added riboflavin in the ration. Good sources are a synthetic compound, fermentation byproducts, dried milk products, and dried brewer's yeast.

Pantothenic Acid

A deficiency in pantothenic acid results in dermatitis of the feet, and crusty scabs appear around the mouth and vent. The eyelids may stick together and growth and feather development are poor. Molasses and fermentation byproducts are good sources of this vitamin. The synthetic compound commonly used as a source is d-calcium pantothenate. Less costly to manufacture than this compound is dl-calcium pantothenate, but 50 percent of it is inactive. Use should be based on d-pantothenate activity.

Niacin

In niacin deficiency, the tongue and mouth cavity become inflamed. Other symptoms include retarded growth, loss of appetite, poor feathering, and scaly dermatitis of the feet and skin. The principal common sources of niacin are the synthetic compound, grains, and the fermentation, grain, and fish byproducts. The niacin in corn is not available to poultry.

Choline

Choline is a factor in the prevention of perosis, or slipped tendons. When the ration is deficient in choline, growth is retarded. The principal source of supplementary choline is choline chloride. Each pound of 25 percent choline chloride supplies 98,518 mg. of choline.

Biotin

A dermatitis results from biotin deficiency. The feet become rough and hemorrhagic cracks appear. Some scabs appear about the beak. Symptoms are similar to those for pantothenic acid deficiency. In pantothenic acid deficiency the first symptoms are around the mouth and eyes, and rarely are the feet severely affected.

Folacin

Folacin, or folic acid, is essential for the normal functioning of virtually all body cells. In broilers a deficiency results in retarded growth, poor feathering, perosis, anemia, lowered resistance to roundworms, and an increased methionine requirement. Most rations are adequate in folacin. Some questionable rations will benefit by the addition of 0.25 mg. per pound of the synthetic compound.

Vitamin B_6

Chicks on a vitamin B_6-deficient ration grow very slowly and often show considerable excitability and jerky convulsive movements. They run about aimlessly, fall on their sides, and paddle their feet in the air. Complete exhaustion follows and is often fatal. The deficiency is rarely seen in the field.

Vitamin B_{12}

Vitamin B_{12} is essential for chick growth. There are no specific symptoms of deficiency. Vitamin B_{12} is associated with animal protein sources. Most rations in which the principal source of protein is of vegetable origin require vitamin B_{12} supplementation. Some sources of B_{12} and the approximate value in milligrams per pound in natural feedstuffs are as follows: Poultry byproduct meal 0.16, feathermeal 0.44, fish solubles 0.20, fishmeal 0.1, and meat scraps 0.05. Generally a commercial vitamin B_{12} supplement is used.

Thiamine

Polyneuritis results if baby chicks are fed a thiamine-low ration for about 10 days. The head of an affected chick is drawn over the back. Other symptoms of deficiency are general weakness, loss of appetite, emaciation, and convulsions. Thiamine deficiency is uncommon.

Unidentified Growth Factors

The unidentified growth factors (UGF) are probably synthesized by the intestinal microflora. At least three distinct organic factors and two or more trace minerals are apparently involved in the UGF. Organic growth factors have been isolated from fish solubles and corn distillers' dried solubles. Other good sources of UGF, trace minerals, or both are alfalfa meal, dried whey, penicillin mycelium residues, streptomyces meal, butyl fermentation solubles, dried and condensed fermented corn extractives, brewer's dried yeast, fishmeal, liver preparations, other animal byproducts, feathermeal, and distillers' grains and solubles. Soybean meal apparently has both water- and fat-soluble factors, which stimulate growth. Liver and corn distillers' solubles contain certain natural chelates, which aid in the utilization of zinc. Feathermeal contains an inorganic unidentified growth factor.

Minerals

The quantity and quality of minerals in the ration are important. Perhaps more important is the relationship of one mineral to another or to some other nutrient. Certain minerals are needed for bone structure and tissues, whereas others are essential for the production of enzymes and hormones. When present in inadequate amounts, nutritional deficiencies may result. If in excess, growth may be depressed, the effectiveness of antibiotics may be adversely affected, and vitamins may be destroyed.

Consideration must be given to the content in the diet of such minerals as calcium, phosphorus, iodine, sodium, manganese, magnesium, potassium, sulfur, and the trace minerals, which include copper, iron, zinc, molybdenum, and selenium. Special consideration is given, in formulating the broiler ration, to calcium, phosphorus, salt, manganese, zinc, copper, iron, and iodine. Interrelationships between calcium and manganese, copper and zinc, and zinc and iron affect requirements. The requirements for minerals are given on pages 32–33.

Calcium

Except possibly for the first week or two, the calcium content of the ration should not exceed 1 percent and the optimum results are probably obtained at about 0.8 percent. To potentiate the broad-spectrum antibiotics, such as chlortetracycline and oxytetracycline, the calcium content of the feed may be lowered to about 0.4 percent. Such a feed is usually given only for 3 days and not during the first 3 weeks. If given too long or when chicks are too young, rickets (leg weakness) may result. (See also p. 51.)

The principal source of calcium in broiler feed is high-calcium ground limestone. Oystershell flour, most sources of phosphorus, and most animal protein feeds also supply liberal amounts of calcium for the ration.

Phosphorus

The amount and the source of phosphorus in the diet are important as well as the relation of the calcium to phosphorus. The vitamin D requirement may be adversely affected by too much phosphorus in the diet. The rate of growth may be depressed. On the other hand, the effect of excess fluorine is greater when phosphorus is deficient in the diet.

Most practical broiler diets will contain approximately 0.65 percent *total* and 0.4 percent *available* phosphorus. Only 30 percent of the phosphorus from plant sources is available. Considerable differences occur in the availability of phosphorus from various inorganic sources. Care should be taken in the use of phosphate supplements of low phosphorus availability and which contain high levels of fluorine, especially in high-energy rations containing added fat. The broiler starter and finisher diets should have about 0.4 percent of nonphytin phosphorus from good animal or inorganic phosphorus sources, such as feed-grade dicalcium phosphate,defluorinated phosphate, or low-fluorine rock phosphate.

Sodium

Sodium is usually added to broiler rations in the form of salt (sodium chloride). In certain areas the water contains relatively large amounts of salt. Normally a broiler feed has about 0.25 percent of salt added.

Manganese

A lack of this mineral is one of the causes of perosis, or slipped tendons, in broilers. It is present to a certain extent in nearly all ingredients of broiler rations. The requirement for manganese is increased by an excess of calcium and phosphorus in combination. To insure an adequate supply of manganese, it is usual to add feeding-grade manganese sulfate to supply 22.7 mg. of manganese per pound of ration.

Iodine

As the broiler rations should contain 0.5 mg. per pound of iodine, iodized salt is usually specified. An iodine deficiency leads to an enlargement of the thyroid gland. Iodine is not usually deficient in broiler feeds.

Zinc

A deficiency of zinc in the ration may cause depressed growth, unsteady gait, shortening and thickening of long bones, frizzled feathers, and parakeratosis of the skin. A high calcium level increases the severity of zinc deficiency symptoms. Natural chelates in certain ingredients aid in the utilization of zinc. Zinc may be of importance because it can activate certain enzyme systems or aid in the absorption of other trace minerals. Common sources of added zinc are zinc carbonate, zinc oxide, and zinc chloride. It is usual to add 50 p.p.m. or 22.7 mg. of zinc per pound to broiler rations.

Iron and Copper

Although the requirements listed by the National Research Council (p. 32) may be too low, practical broiler rations normally contain adequate amounts of iron and copper without the use of additives. Zinc causes a strong antagonism to iron and copper, especially copper. A deficiency of iron especially can cause anemia, rough feathering, and lighter colored feathers in red varieties. A deficiency of copper may result in poor growth and a high mortality, largely due to spontaneous aortic rupture. As a margin of safety, 1.816 mg. of copper per pound may be included in the finisher ration.

Molybdenum and Selenium

Chicks require molybdenum and selenium, but probably added amounts are not needed in practical formulation. As a margin of safety, 0.0454 mg. of each per pound may be added.

Magnesium

Magnesium is an essential element and must be provided from a dietary source. It is required as an activator for many enzymes. Deficiency symptoms are poor growth, tremors, gasping, and convulsions. The requirement is less in the presence of antibiotics and is greater with contamination, as with chicken feces, or with increased calcium or phosphorus in the ration. Magnesium does not need to be added to a practical broiler ration.

FEED AND WATER CONSUMPTION

Table 4 gives the approximate feed and water consumption per 1,000 mixed-sex commercial broilers. The feed consumption will vary with the strain, the texture, energy, and protein content of the ration, environment (such as temperature), management, and disease problems. Water intake varies with the temperature, diet, and feed intake. When the temperature is about 70° F., the water consumption varies from 1½ to 2 pounds of water for every pound of feed consumed. Nearly 2½ times more water is consumed per pound of feed at 90° than at 60°. Extra salt in the diet will increase the water consumption. Adequate quantities of water should be available for broilers to fulfill their individual needs.

TABLE 4.—*Approximate feed and water consumption per 1,000 broilers* [1]

Week	Feed per day	Feed per week	Accumulative feed	Water per day
	Pounds	*Pounds*	*Pounds*	*Gallons*
1	33	231	231	7
2	60	420	651	13
3	90	630	1,281	19
4	117	819	2,100	25
5	145	1,015	3,115	31
6	200	1,400	4,515	46
7	262	1,834	6,349	55
8	291	2,037	8,386	61
9	301	2,107	10,493	63

[1] Assume a room temperature of 70° F.

RATION INGREDIENTS

Grains

Grains are included in the ration primarily as a source of energy and secondly for their protein and amino acid content. The low-energy grains, barley and oats, contribute more of the B-complex vitamins and minerals than the high-energy grains. All grains are thought to carry some unidentified growth factors. For broilers, corn is the best grain. As a source of energy, if corn is given a value of 100, the comparative values for the other grains would be about 88 for wheat, 87 for barley, and 84 for oats. If used, wheat should be coarsely ground. The feeding value of some barleys has been improved by soaking them in water, adding certain enzyme preparations, or adding fat to the diet. Replacing corn with oats usually results in slower growth and poorer feed conversion. Oat groats, or dehulled oats, compare favorably with corn or wheat.

Corn is a source of the carotenoid pigments, which provide provitamin A and pigmentation factors. In rations containing 2.5 percent or more of alfalfa meal or 2.5 percent or more of corn gluten meal, milo can replace half of the yellow corn when the price is right. In general, cereals are deficient in riboflavin, vitamin B_{12}, choline, and phosphorus. Molasses is sometimes used at low levels to replace corn or milo.

Millfeeds

Wheat bran improves the palatability of a feed, but it has a low content of digestible nutrients and is not used in high-energy rations. Wheat middlings and shorts can be economical sources of energy. They are a better source of the B-G complex factors than the cereal grains.

Fat

The amount of fat added to a commercial broiler feed varies considerably. It may range from about 1 to 10 percent. The relative cost and availability of fats of acceptable quality are important considerations. In general, the amount to add is what is required to produce a pound of chicken at the least possible cost. Most broiler rations will include 2 to 4 percent of added fat, which brings the total fat content to 6 to 8 percent. The use of levels of fat above 2 to 3 percent in pelleted feeds must be justified entirely on the relative cost of energy. Pelleting a low-fat ration improves both growth and feed conversion, but pelleting a high-fat ration does not. Mash feeds may be improved in feed efficiency and sometimes in growth by adding 10 percent of fat. The principal reason for improved results from both pelleting and high fat levels is an increase in nutrient intake. Efficient feed conversion depends to a considerable extent on the total energy content of the diet, which is the sum of the energy derived from fat, carbohydrate, and protein.

Fats may make mash feeds less dusty and enhance their texture and palatability. They may also cause feed to "hold up" in bins and feeders and may cause poor-quality pellets, which break down to fines. Equipment has been developed for incorporating fats in mashes and pellets. Antioxidants are blended with fats to reduce the rancidity and the destruction of nutritive factors such as vitamins A and E.

For general calculations, 2,900 calories of productive energy and 3,500 calories of metabolizable energy are used for fats when exact values are not known.

Fish Oil

The addition of fish oil may improve growth and feed efficiency. Care must be taken to avoid fishy flavor. The amount used will depend on the amount and kind of fishmeal in the ration. The maximum fish oil, without fishmeal in the ration, is 2½ percent.

Animal Protein Products

The animal protein products—fishmeal, meat scrap, and crabmeal—contain relatively high quantities of the essential amino acids, vitamin B_{12}, riboflavin, and choline. Combining several animal and vegetable protein sources is usually advantageous. Synthetic methionine and lysine are commercially available and their use is sometimes indicated.

Fishmeal

Most starter rations, without other sources of animal protein or unidentified growth factors of the "fish" type, are improved by adding 2.5 to 10 percent of high-quality fishmeal. It is probably not advantageous to exceed 7.5 percent of fishmeal in the finisher rations. The level to use will depend primarily on the kind and cost of the fishmeal in relation to other protein sources. Fishmeal is a good source of the B-G complex vitamins.

Condensed Fish Solubles

Made from fish waste, condensed fish solubles are a source of the "fish" factor and of the B-G complex factors, especially vitamin B_{12}. This product is usually shipped in tank cars.

Meat Scrap

Meat scrap and meat and bone scrap are byproducts of the rendering industry. They average 50 percent in crude protein. The lower the protein content, the higher the bone content. The use of meat scrap in broiler rations will depend on its relative cost as compared to fishmeal, soybean meal, feathermeal, and poultry byproduct meal.

Crabmeal

Commercial crabmeal has the following percent constituents: Protein 32, crude fat 1, crude fiber 13, ash 42, calcium 16, phosphorus 1.6, and salt 3. Crabmeal can replace fishmeal and meat and bone scrap if adjustment is made for calcium, phosphorus, and riboflavin. Crabmeal has about the same content of unidentified growth factors as fishmeal.

Feathermeal

The hydrolyzed feathermeals vary greatly in protein quality. Feathermeal has a relatively poor quality of protein compared to fishmeal, poultry byproduct meal, or soybean meal. It contains about 80 percent of crude protein and 800 calories of productive energy. It is relatively high in amino acids, glycine, cystine, and arginine, but low in methionine and lysine. It contains an unidentified inorganic growth factor. Its use is limited to 5 percent or less of the poultry ration. Results are not improved by supplementing feathermeal with massive doses of amino acids or extra vitamins and minerals.

Poultry Byproduct Meal

Poultry byproduct meal is usually guaranteed to have 55 percent of crude protein and 12 percent of fat. It has a productive energy content of about 900 calories per pound, about equal to fishmeal and higher than meat and bone scrap or soybean meal. If correction is made for calcium and phosphorus, this product can substitute for all the meat scrap and half the fishmeal, provided at least 2.5 percent of fishmeal remains in the ration. It is low in methionine, lysine, and cystine and needs animal protein supplementation.

Vegetable Protein Sources

Soybean Meal

The 50 percent dehulled and 44 percent solvent-extracted soybean meals have largely replaced other types in this most widely used source of vegetable protein in broiler rations. Soybean meal, either 50 percent dehulled or 44 percent extracted, and ground yellow corn are the principal ingredients in most least cost broiler rations. Soybean meals may be deficient in certain amino acids, especially methionine, vitamin B_{12}, and unidentified growth factors.

Cottonseed Meal

A commercial prepress solvent cottonseed meal will contain about 600 calories of productive energy per pound (air dry basis) if it contains 44 to 47 percent of protein and has a protein solubility of 74 percent or more. It can be of equivalent nutritive value to soybean meal if fed on an equal energy basis and is supplemented with lysine and if the soybean meal is supplemented with methionine. Fifty percent protein dehulled soybean meal will have about 640 calories per pound. Cottonseed meal will have a higher crude fiber content than soybean meal. It is best used as partial replacement of other vegetable protein sources.

Corn Gluten Meal

Corn gluten meal is used up to 5 percent of the ration as a protein source to replace part of the soybean meal, and it is used at about 2 percent of the ration to improve pigmentation, especially the finisher diet and when yellow cornmeal is replaced by nonpigmented grains. It is low in lysine, arginine, and tryptophan.

Sources of Natural Vitamins and Unidentified Growth Factors

Distillers' Dried Solubles

Corn and milo distillers' dried solubles are used primarily as a source of "fermentation" unidentified growth factors at levels of 2.5 or 5.0 percent, replacing soybean meal and ground corn. They are a good source of energy and the B-G complex vitamins.

Fermentation Products

Various products, both primary and byproduct, are excellent sources of the unidentified growth factors. They are often high in vitamins and may contain residual amounts of antibiotics.

Alfalfa Meal

Although alfalfa meal is included in the broiler ration primarily for its provitamin A, beta-carotene activity, and its xanthophyll content, it also contains substantial amounts of vitamins, including vitamins E and K. Most commercial alfalfa meals have an antioxidant, such as ethoxyquin and fat added, are blended, stored under gas, and ground before use. With the advent of high-energy rations, there has been less 17 percent protein meal used and a trend toward 20 percent meals in broiler feeds. When nonpigmented grains replace yellow corn, 2 percent of alfalfa meal is often included in the ration.

Dried Whey

Some rations are improved by the addition of the "whey" unidentified growth factor. Because of its laxative effect and sometimes its cost, the use of dried whey is generally restricted to a maximum of 2½ percent of the ration.

Antioxidants

Antioxidants are used in broiler rations to protect against rancidity and the oxidative destruction of vitamins A and E in storage, mixing, and pelleting and to increase the utilization of provitamin A from alfalfa meal. Butylated hydroxytoluene (BHT) and 1,2-dihydro 6-ethoxy-2,2,4-trimethylquinoline (Santoquin and Dethoxyquin) are common antioxidants for broiler feeds. They are used at a level of 0.0125 percent to prevent encephalomalacia and the destruction of the fat-soluble vitamins A and E. They do not improve pigmentation or the dietary utilization of xanthophyll in broilers unless oxidizing agents, such as lineoleic acid, are present. Antioxidants do not appear to have a specific function in preventing selenium and vitamin E-induced deficiencies.

Coccidiostats

A coccidiostat is used in most broiler rations to prevent coccidiosis. The suggested level is that recommended by the manufacturer. Care should be taken to limit the percentage used to the requirements of the situation and to be sure the drug is removed from the ration at marketing time according to regulations. When a coccidiostat is used, special consideration should be given to the vitamin A and K content of the ration.

Some of the coccidiostats commonly used in broiler rations are as follows:

Amprolium, Amprol 25 percent (1-(4-amino-2-n-propyl-5-pyrimidinylmethyl)-2-picolinium chloride hydrochloride)
Arzene (arsenosobenzene)
Glycarbylamide, Glycamide (4,5-imidazole-dicarboxamide)
Nicarbazin, Nicarb (4,4'-dinitrocarbanilide-2-hydroxy-4, 6-dimethylpyrimidine)
Nitrofurazone, NFZ (5-nitro-2-furaldehyde semicarbazone)
Nitrofurazone and furazolidone, Bifuran (5-nitro-2-furaldehyde semicarbazone and n-(5-nitro-2-furfurylidene)-3-amino-2-oxazolidone)
Nitrophenide, Megasul (m,m-dinitrodiphenyldisulfide)
Polystat (acetyl-(para-nitrophenyl)-sulfanilamide, dibutyltin dilaurate, dinitrodiphenylsulfonylethylenediamine, 3-nitro-4-hydroxyphenylarsonic acid)
Sulfaquinoxaline, SQ (2-sulfanilamidoquinoxaline)
Trithiadol (bithionol and methiotriazamine)
Unistat (acetyl-(para-nitrophenyl)-sulfanilamide, 3,5-dinitrobenzamide, 3-nitro-4-hydroxyphenylarsonic acid)
Whitsyn (2,4-diamino-5-(para-chlorophenyl) 6-ethyl pyrimidine and 2-sulfanilamidoquinoxaline)
Zoalene, Zoamix (3,5-dinitro-o-toluamide)

Antibiotics

Most broiler rations contain antibiotics at the relatively low levels of 4 to 10 grams per ton to stimulate growth. Some of those commonly used are penicillin, bacitracin, zinc bacitracin, erythromycin, chlortetracycline, and oxytetracycline. Improved results are sometimes obtained by combining antibiotics or by changing antibiotics periodically.

Chicks in contaminated quarters may show depressed growth from the fourth to the seventh day. This symptom was not observed when an antibiotic was included in the diet. The feed is apparently poorly utilized from the 4th to the 12th days by the chicks not getting the antibiotic. Fecal excretion is greater when an antibiotic is not given. Antibiotics seemingly improve growth and feed utilization by affecting the micro-organisms, which reduce absorption of nutrients. Results from antibiotics are highly variable. Sometimes males respond when females do not. The age and extent to which different breeds and strains respond may vary with different antibiotics. Reasons for the complexity of antibiotic action are not known.

Levels of 100 grams per ton or more are used in some prestarter rations to be fed for the first 14 to 21 days. High levels of antibiotics are also used for disease control.

The broad-spectrum antibiotics—chlortetracycline and oxytetracycline—are often potentiated when used to control certain diseases. The amount and the sources of certain minerals in the ration affect the concentration of the antibiotics in the blood of the bird. The manufacturer's recommendations should be followed in the use of antibiotics.

Antibiotics commonly used in broiler rations and their principal functions are as follows:

Antibiotic	*Function* [1]
Aureomycin, aurofac, chlortetracycline	Growth promotion; aid in prevention and control of chronic respiratory disease (CRD) and synovitis.
Bacitracin	Growth promotion; aid in prevention and control of CRD and blue comb; meet stress conditions.
Bacitracin, manganese	Growth promotion.
Bacitracin methylene disalicylate	See Bacitracin.
Bacitracin, zinc	Do.
Erythromycin, Gallimycin, erythromycin thiocyanate	Growth promotion; aid in prevention and control of CRD.
Oleandomycin	Growth stimulation.
Oxytetracycline, oxytetracycline hydrochloride, terramycin	Growth promotion; aid in reduction of CRD mortality; aid in prevention and control of synovitis.
Penicillin, procaine penicillin	Growth promotion; aid in prevention and treatment of CRD, blue comb, and synovitis.
Penicillin (from procaine penicillin), streptomycin	Growth promotion; treatment of CRD and blue comb.

[1] The function of the antibiotic is dependent on the level of the drug in the feed. For more detailed information, refer to Food and Drug Administration Antibiotic Regulations, obtainable from the Office of Information, Food and Drug Administration, 200 C St. SW., Washington, D.C. 20204.

Antibiotic Potentiation

When broad-spectrum antibiotics, such as chlortetracycline and oxytetracycline, are used to control diseases, it is economical and feasible to potentiate them.

Calcium is the principal inhibitor of antibiotics in poultry feeds. On the other hand, the calcium salt, calcium sulfate, is less inhibitory and can be used to advantage. Sodium sulfate also can be used as a substitute for calcium carbonate or dicalcium phosphate to increase concentration of the antibiotics in the blood. Due to its tendency to increase water consumption when used in excessive amounts, it is advisable to restrict the percent of sodium sulfate to 1.5 in potentiating formulas. When using formulas to potentiate antibiotics, the directions of the manufacturer of the antibiotic should be followed. If it is approved for use, terephthalic acid (T.P.A.) will also enhance the therapeutic efficiency of Aureomycin.

Arsenicals

Low levels of certain arsenicals have a growth effect similar to that of antibiotics. Arsenicals and antibiotics usually give a greater growth response when combined than if used separately. For example, the addition of arsanilic acid or "3-nitro" to bacitracin methylene disalicylate will give a better gain and feed conversion than the antibiotic alone. The pigmentation of the birds fed on arsenicals is often improved. Arsanilic acid (p-aminobenzenarsonic acid) or sodium arsanilate and 3-nitro-4-hydroxyphenylarsonic acid are the commonly accepted arsenical sources. Arsanilic acid or sodium arsanilate is used at 45 to 90 grams per ton and "3-nitro" at 22.5 to 45 grams per ton of ration. The directions of the manufacturer should be followed for the other compounds.

Hormones

Dienestrol diacetate, a synthetic compound with hormonelike activity, has been mixed with feed to increase fat deposition and to give improved carcass quality. When any product of this kind is used, the manufacturer's directions and the Food and Drug Administration's regulations should be followed.

The Consumer and Marketing Service's poultry inspection program includes laboratory testing procedures for determining chemical residues in poultry products. Failure to heed directions for use and withdrawal periods may result in poultry products being condemned as unwholesome.

Xanthophyll

In most areas, customers prefer highly pigmented birds. The variation in skin color is due primarily to breed, method of scald, and the xanthophylls in the feed ingredients of the rations. Xanthophylls are a group of carotenoid pigments. Good pigmentation usually results when at least 6.4 mg. of xanthophyll from natural sources are present in each pound of feed. If low carotenoid ingredients, such as milo or white corn, are used in a starter ration, good pigmentation can still be obtained by using about 8 mg. of xanthophyll per pound in a finisher ration. Most finishers have at least this level. Approximate available xanthophyll values for ingredients mostly responsible for pigmentation in broilers are given on page 43.

Miscellaneous Additives

Some of the miscellaneous additives used in broiler rations and their functions are as follows:

Additive	*Function*
Aterrimin	Growth stimulant.
Dynafac	Growth promotion and feed conversion.
Furazolidone, nf-180	Chemotherapeutic agent for growth promotion and prevention and treatment of fowl typhoid, paratyphoid, pullorum disease, and CRD.
Neomycin, neomycin sulfate	Used for bacterial enteritis.
Nystatin, Mycostatin	For prevention and treatment of crop mycosis and mycotic diarrhea.
Reserpine	To combat stress conditions.
Sulfathiazole sodium	To control spread of infectious coryza.

RATION FORMULATION

The formulation of a practical broiler feed is the combining of selected ingredients to meet specific nutritive requirements and often processing and pricing limitations. Ingredients are classified on the basis of the nutrient in which they are rich; for example, carbohydrates, vegetable proteins, animal proteins, vitamins, stabilized fats, minerals, and miscellaneous additives.

The choice of ingredients within a class depends largely on composition, availability, and price. The feed formulator chooses the ingredients that, when combined, provide the required nutritive value at the lowest possible cost. The value of ingredients and formulated feeds should, whenever possible, be based on actual feeding results. When a product of doubtful value is used in an effort to provide plenty of a nutrient, the result can be a dangerous imbalance; for example, the use of feathermeal to supply all the protein in a ration if it happened to be the cheapest source of protein.

The approximate composition of complete broiler rations by ingredient classes can be used as a guide and is as follows:

Ingredient class	*Percent of ration*
Carbohydrates [1]	55–60
Vegetable proteins [2]	20–30
Animal proteins [3]	2.5–20
Vitamins [4]	2–8
Stabilized fats [5]	0–8

[1] Grains and grain byproducts: Corn, wheat, barley, oats, millet, shorts, middlings, red dog, hominy feed, etc.

[2] Soybean, corn gluten, cottonseed, peanut meals.

[3] Fishmeal, fish solubles, meat scrap, liver meal, dried milk, feathermeal, poultry byproduct meal, etc.

[4] Commercial vitamin supplements, alfalfa, dried whey, dried yeast, distillers' solubles, fermentation solubles, etc.

[5] Grease, tallow, poultry oil, etc.

Mineral carriers [6]	1–3
Miscellaneous [7]	----

[6] Limestone flour, oystershell flour, dicalcium phosphate, steamed bonemeal, defluorinated superphosphate, defluorinated rock phosphate, iodized salt, manganese sulfate, etc.

[7] Trace amounts of these ingredients may be added. Many are present in commercial rations, but some may not be necessary under all conditions. The group includes antibiotics, coccidiostats, arsenicals, hormones, antioxidants, and xanthophyll.

The specifications or allowances for practical broiler rations are constantly changing. For a tentative set for starter and finisher rations used as a basis for linear programing, see tables 6 and 7 (p. 46).

For the composition of ingredients commonly used in poultry feeding, see Joint United States-Canadian Tables of Composition.[4] These values will prove a reliable guide in choosing and using ingredients. Suppliers of ingredients will usually furnish the analysis of their products as well as guarantees. Table 5 gives the composition of selected ingredients to illustrate an example in linear programing.

Whenever possible the formulator should utilize the actual chemical analyses of the ingredients to be used. In addition, digestibility, palatability, and the effect on the appearance of the bird should be considered. Actual feeding tests, when available, are of greatest importance.

Attention must be paid to the interrelation of nutritional factors, some of which have been indicated (see pp. 36–37). Examples are the protein-amino acid and the calcium-phosphorus ratios. Proper nutrition balance is especially important when environmental heat is excessively high.

The productive energy of practical broiler feeds probably varies from 900 to 1,100 calories per pound and the metabolizable energy from 1,350 to 1,500 calories per pound. The optimum ratio of calories to protein content may be different depending primarily on the quality of the protein. As a guide, the optimum ratio for starting diets is usually considered to be 42 to 45 calories of productive energy and 60 to 65 calories of metabolizable energy to each percent of crude protein in the ration. The corresponding figures for finishing diets are 48 to 53 and 69 to 75 and for withdrawal diets, 60 to 85. The ratios vary with the quality of the protein. The better the balance of the amino acids, the wider the ratio that can be used. When the ratio is low, less fat is deposited. The protein requirement of 20 percent (p. 32) will meet the approximate minimum requirement for growth in rations containing 900 calories of productive energy per pound.

Since the food intake of the growing broiler is proportionate to its energy requirements, the protein, amino acid, vitamin, and mineral levels needed in the ration are related to the energy content of the ration. As the energy content of the ration increases to 1,450 calories of productive energy, as by the addition of high levels of dietary fat, the needed level of all required nutrients, especially vitamins and minerals, is substantially increased. This is also true when feed intake is reduced for other reasons.

As the energy content of the ration increases, the percent protein required also increases if the best growth and feed conversion are desired. Some feed formulators maintain a constant ratio of calories to protein content for their starter, finisher, and withdrawal feeds. In practical formulation, where energy and protein levels do not change much, consideration should be given to expressing amino acid requirements on an energy basis. The ratios of amino acids to energy would appear to be a more direct means of insuring amino acid adequacy and thus avoid the necessity of considering the ratio of calories to protein as such.

Requirements for the amino acids are all interrelated, and they are related to the levels of total protein and energy. In general, the levels required of the amino acids, expressed as a percent of the ration, are higher as the protein content increases. As an example, if the protein content is 24 percent, the percent of the ration for each amino acid can be obtained by multiplying the percentages given on page 33 for a ration having a 20 percent protein level by 24/20 or factor 1.2. Since protein quality may vary markedly, recent guides for use in the formulation of poultry feeds have expressed amino acid levels as a direct function of the energy level. Up to the optimum energy utilization by the bird, the requirement for methionine, lysine, glycine, and arginine goes up as the energy content of the ration increases.

In most broiler rations the sulfur amino acids (methionine and cystine) and lysine have to be considered most critically. The indications are that the minimum levels to be used should be on an energy basis. For example, for best growth and feed efficiency, the ratio of minimum sulfur amino acids (methionine and cystine) to metabolizable energy should be about 0.53 percent for starters and 0.48 percent for finishers. The corresponding values on the basis of productive energy would be obtained by multiplying by 1.43. Because of the varying response of amino acid supplementation with different diets, other factors also may have to be considered. Whenever feed intake is decreased, for example in hot weather, all nutrients should be increased in rela-

[4] NATIONAL ACADEMY OF SCIENCES, NATIONAL RESEARCH COUNCIL. JOINT UNITED STATES-CANADIAN TABLES OF COMPOSITION. Pub. 659, 80 pp. Washington, D.C. 1959.

TABLE 5.—*Analysis of ingredients commonly used in broiler feeds*

Ingredient	Protein	Fat	Fiber	Metabolizable calories per pound	Productive calories per pound	Calcium	Phosphorus	Vitamin A	Riboflavin	Pantothenic acid	Niacin	Choline	Methionine	Methionine and cystine	Tryptophan	Arginine	Lysine	Glycine	Xanthophyll
	Percent	*Percent*	*Percent*	*Number*	*Number*	*Percent*	*Percent*	*U.S.P. units per pound*	*Mg. per pound*	*Mg. per pound*	*Mg. per pound*	*Mg. per pound*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Mg. per pound*
Alfalfa, 20 percent	20.0	2.5	18.0	740	310	1.70	0.09	90,000	8.4	18.4	20.4	425	0.37	0.75	0.30	1.00	0.96	1.00	115
Alfalfa meal, 17 percent	17.0	2.5	26.0	620	250	1.40	.06	60,000	6.7	16.0	13.0	400	.33	.64	.27	.86	.83	.90	90
Corn, ground yellow	8.9	3.9	2.2	1,545	1,105	.02	.08	900	.5	2.3	9.6	200	.18	.34	.10	.43	.20	.43	8
Molasses, cane	3.2	.1		900	700	.89	.08		1.5	17.4	15.6	398							
Hominy feed	10.7	6.5	5.0	1,300	850	.04	.53	600	.9	3.4	23.2	460	.17	.30	.55	.49	.34	.28	2
Milo	8.5	2.8	2.0	1,505	1,099		.33		.6	5.8	22.0	346	.10	.30	.10	.40	.30	.36	
Middlings, standard	17.2	4.6	8.0	890	694	.15	.91		.9	9.0	44.8	488	.20	.40	.20	.90	.70	.35	
Corn gluten meal, 41 percent	41.9	2.3	4.0	1,177	840	.16	.40	2,400	.7	4.7	22.7	150	1.00	1.60	.20	1.40	.80	1.35	60
Soybean meal, 50 percent	50.9	.8	2.8	1,120	790	.26	.19		1.8	6.8	15.3	1,330	.70	1.44	.76	3.83	3.20	2.71	
Soybean meal, 44 percent	46.1	1.0	5.0	1,020	761	.32	.18		1.5	6.6	17.6	1,247	.60	1.20	.60	3.60	2.90	2.45	
Meat and bone, 50 percent	51.0	9.4	2.3	900	720	10.00	4.81		2.1	1.6	21.4	900	.70	1.30	.30	3.50	3.50	6.60	
Poultry byproduct meal, 55 percent	55.0	12.0	2.5	1,280	900	4.00	2.00		5.0	4.0	18.0	2,720	.96	1.96	.45	3.50	3.70	2.85	
Feathermeal	85.0	3.4	1.4	1,078	600	.20	.75		.9	4.0	8.0	400	.52	2.82	.57	5.60	1.50	4.76	
Fishmeal, menhaden, 60 percent	61.3	7.7	.9	1,350	920	5.11	3.28		2.5	4.0	25.4	1,250	1.80	2.50	.70	4.00	5.30	4.10	
Crabmeal	31.0	2.2	10.5	850	600	14.50	1.50		2.7	3.0	20.0	920	.43	.51	.25	1.45	1.20	1.80	
Fish solubles, condensed	31.4	6.5	1.0	650	450	.10	.70		6.6	16.1	76.7	1,831	1.00	2.70	.80	2.40	2.70	2.74	
Distillers' dried solubles	26.9	9.1	4.0	1,330	1,020	.35	1.37		7.7	9.5	52.4	2,190	.60	1.20	.20	.90	.90	1.10	1
Dried whey, delactosed	16.8	1.5		830	786	.87	.79		27.2	31.2	27.1	797	.10	.46	.10	.20	.80	.70	
Poultry oil		100		3,580	2,900														
Stabilized fat		100		3,500	2,900														
Limestone						38.00													
Defluorinated phosphate						32.00	14.00												
dl-Methionine													100	100					

tion to energy by about 7.5 percent or in proportion to the drop in feed consumption when it is known. To meet the sulfur amino acid levels needed by broilers, it may be necessary to add to high corn rations from 0.5 to 1.5 pounds per ton of methionine and to high milo diets as much as 2 pounds.

On analysis sheets the protein, fat, fiber, calcium, phosphorus, salt, and amino acids are usually listed as percentages, vitamin A as U.S.P. units per pound, and vitamin D_3 as international chick units (I.C.U.) per pound. The rest of the vitamins, except vitamin B_{12}, and the minerals are listed as milligrams per pound. The vitamin B_{12} content is sometimes given in micrograms (1/1,000 mg.) per pound. Sometimes minerals, coccidiostats, and other additives are given in percentages or parts per million (p.p.m.). The conversion formula is 0.01 percent equals 100 p.p.m. equals 90.8 grams per ton. To shift percentages to parts per million, the decimal point is shifted to the right four places. There are 454 grams in a pound. To convert milligrams per pound to grams per ton, multiply by 2. To convert parts per million to grams per ton, multiply by 0.908.

When formulating rations, the source of phosphorus must be considered. The phosphorus from sources other than supplements is only about 30 percent available and that from various supplements varies greatly. Both the total and the available phosphorus content of the ration must be considered. If an 18 percent dicalcium phosphorus product (18 percent of phosphorus, 26 percent of calcium) is listed, steam bonemeal or defluorinated rock phosphate may replace it on a phosphorus content basis. If a 14 percent product with equal availability is used, calcium must be adjusted.

Thirty percent of milo, 20 percent of wheat, both coarsely ground, or 10 percent of hominy feed can replace yellow cornmeal. If milo or wheat is used, the birds will be less pigmented. If milo replaces corn, the methionine content of the ration will probably have to be increased. For each 100 pounds of corn replaced by wheat or milo, 200,000 U.S.P. units of vitamin A should be added to the ration. If stored ingredients are used, the vitamin A content should be increased 1,000 U.S.P. units per pound. To meet stress conditions, 0.5 mg. of menadione sodium sulfite (vitamin K_3), or its equivalent in vitamin K_1, per pound of ration is added.

It is usual to specify technical grade or 70 percent feeding-grade manganese sulfate, 95 percent calcium carbonate limestone, and 100 percent choline chloride, or their equivalents. Choline chloride (100 percent) contains 86.79 percent of choline. One pound of 100 percent choline chloride contains 394,027 mg. of choline. If calcium pantothenate is used, the amount should depend on the guarantee of d-pantothenic acid activity for the product. The "l" form is inactive. A half pound of manganese sulfate (70 percent) per ton of ration will provide 50 grams of manganese. To supply the usual 22.7 mg. per pound of zinc, 45.4 grams of zinc must be added per ton of ration. To supply this will require either 104 grams of zinc chloride or 62 grams of zinc oxide per ton of ration. An equivalent amount of zinc may be used from other acceptable sources.

Factors Affecting Feathering

The factors affecting feathering most include protein, folic acid, biotin, pantothenic acid, and vitamin B_{12}. Diets low in protein or with poor amino acid balance will give poor feathering. In general, factors that promote rapid growth rate also induce good feathering.

Linear Programing

More economical production of broilers has resulted from linear programing in feed formulation. Linear programing is the formulation of rations to meet specified nutritional requirements and yet cost less; hence the name least cost diets. To be practical, the solution must result in least cost manufacturing. It is necessary for the nutritionist programer to have a list of representative delivered prices of all the ingredients to be considered, their nutrient content, nutrient specifications for the feed, and nutritional restrictions, including fixed maximum and minimum amounts.

Linear programing sometimes includes nonnutritive restraints. These may be determined by the lack of availability of ingredients and their physical properties, whether bag or bulk. Machine formulation is of value in planning nutritional research, better utilization of the time of the nutritionist, more rapid application of research results, greater savings, better evaluation of the value of ingredients, more precise nutrient content and balance of rations, and better production management in the mill.

It is not necessary and probably is inadvisable for most firms to have a computer. The size needed is so large that such a computer could not generally be utilized enough hours to be effectively employed. The use of a computing service is usually the only feasible way to get the job done. When the prices of ingredients, such as corn or soybean meal, fluctuate widely, it may be feasible to reformulate feeds as often as weekly for maximum benefits from programing.

Linear programing has its limitations. More research is needed on the composition of many ingredients and especially on rapid methods of determining their biological value. For example, the protein of corn and milo and the amino acid content of fishmeal vary considerably. Data are insufficient on the nutrient content and feeding value of ingredients, such as feathermeal, poultry byproduct meal, blood meal, corn gluten feed, hominy feed, and molasses. The value of ingredients differs depending on the level used and how they are combined with other ingredients. The level of fat is an example. In addition, there are nonnutritive restraints. Examples are the availability of ingredients, mill storage facilities, size of the mixer, fire danger during storage, unit size, tag registrations, and such physical characters of ingredients as flowability, color, odor, palatability, and pelletability. These restraints vary with every feed-manufacturing plant.

Considerable experience is needed in knowing how to adjust for seasonable effects, to price ingredients, to arrive at safety factors, to place restriction and restraints, and to determine what cost differences justify the usual high cost of reformulation. Linear programing is helping ingredient purchasing by "shadow pricing." This is the process by which ingredients, through restrictions, are rejected at certain prices and used in larger amounts at lower prices. The machine determines the "slack" and the "excess" values below and above the maximum and the minimum restrictions, respectively.

Care must be used in establishing a restriction, since the use of a maximum restriction on a nutrient that could be present in excess with no effect on performance will increase the cost of the formula without improving its nutritive value. This is particularly true with amino acids that are not first limiters. If the amino acids are restricted, it may not be necessary or advisable to restrict the protein content. A similar situation may exist with fat and energy. However, the amino acid-energy ratios should not be overlooked.

The ratio of percent of methionine and cystine to megacalories (1,000 calories) of metabolizable energy per pound should be about 0.56 for the starter and 0.51 for the finisher ration, and for lysine the ratio should be 0.87 for the starter and 0.71 for the finisher ration. These values may be converted to actual percentages needed in the feed by multiplying them directly by the therms (1,000 calories) of metabolizable energy per pound. For example, for a feed with 1,400 calories, multiply by 1.4 ($1.4 \times 0.56 = 0.78$) to obtain the requirement for the total sulfur amino acids (methionine and cystine) for the starter of 0.78.

The manipulations involved in determining the best formula will depend on the specific program and the computer used. A computer solution is only as good as the assumptions put into the program. Future benefits of linear programing will depend on the improved skill of the nutritionist-buyer-programer team and the better nutrient description of ingredients. Actual feeding results are, in the meantime, the best assurance of correct formulation and should supplement the rapid precise calculations of the computer.

Table 6 gives an example of the restrictions placed on nutrients and table 7 the ingredient limitations in linear programing for least cost broiler formulas. Table 8 gives examples of typical broiler starter and finisher formulas resulting from the model chosen. Least cost rations may give as good results as manually computed rations at several dollars less per ton. The formulas given are good, but are not recommended as meeting any but the conditions of this particular program at the prices used. When these formulas were used for 43,693 broilers at the South Central Poultry Research Laboratory, State College, Miss., the average weight of the birds at 9 weeks of age was 3.96 pounds, the feed conversion 2.2 pounds, and the mortality only 2.1 percent.

The constant premix (table 7) was as follows:

Item		*Amount*
Vitamin A palmitate (stability improved)	U.S.P. units	600,000
Vitamin D_3	I.C.U	200,000
Riboflavin	mg	800
Niacin	mg	5,000
d-Pantothenic acid	mg	1,600
Choline chloride	mg	80,000
Vitamin B_{12}	mg	1.200
Ethoxyquin	grams	12
Menadione sodium bisulfite	mg	200
Iodine	percent	.050
Manganese	do	3.000
Iron	do	.800
Copper	do	.080
Zinc	do	.881

Concentrates and Premixes

Feed mixers often find it advantageous to use one or more manufactured concentrates for blending with ground yellow corn or other grains. It is possible to buy broiler starter and broiler finisher concentrates or a single concentrate for producing both feeds. A single concentrate for several feeds is usually less economical and less satisfactory than separate concentrates for each feed. Generally 800 pounds of ground yellow corn are used to produce a ton of broiler starter feed. To make finishers, 700 and sometimes only 600 pounds of broiler finisher concentrate are mixed with 1,300 or 1,400 pounds of corn.

A multipurpose concentrate must be formulated to meet its most critical use. Special concentrates, superconcentrates, or premixes are

TABLE 6.—*Typical nutrient specifications for least cost broiler rations* [1]

Item	Broiler starter	Broiler finisher
Maximum ______________pounds____	1,000	1,000
Metabolizable calories per pound, exactly____number____	1,400	1,450
Protein ________________percent____	(2)	(2)
Fat ____________________do______	(2)	(2)
Fiber, maximum ________pounds____	35	35
Calcium, exact ____________do______	9	7
Inorganic phosphorus available, exactly ________do______	4.5	3.5
Arginine [3] ________________do______	12	10.8
Lysine [3] __________________do______	12	10.8
Methionine [3] ______________do______	4.1	3.7
Methionine [3] and cystine____do______	7.8	7.0
Tryptophan [3] ______________do______	2.1	1.9
Xanthophyll [4] ______________mg____	6,000	8,000

[1] All minimum unless otherwise indicated.
[2] Unrestricted.
[3] Per 1,400 calories.
[4] Per 1,000 calories.

TABLE 7.—*Typical ingredient restrictions for broiler formulas in linear programing*

Item	Broiler starter	Broiler finisher
	Pounds	*Pounds*
Pounds, maximum ________________	1,000	1,000
Soybean meal, 50 percent __________	(1)	(1)
Fishmeal, 60 percent:		
Minimum ____________________	50	50
Maximum ____________________	150	150
Poultry byproduct meal, 55 percent:		
Minimum ____________________	50	50
Maximum ____________________	400	400
Corn gluten meal, maximum _______	200	200
Prostrep, exact ____________________	.375	.25
"3-nitro," 45 grams, exact __________	.5	.5
or		
Progen arsanilic acid, 90 grams, exact __________________________	.5	.5
Alfalfa meal, 20 percent:		
Minimum ____________________	20	20
Maximum ____________________	40	40
or		
Alfalfa meal, 17 percent:		
Minimum ____________________	20	20
Maximum ____________________	40	40
Dried whey (MNC), exact _________	25	________
Molasses, cane:		
Minimum ____________________	50	50
Maximum ____________________	60	60
Poultry oil, maximum _____________	120	120
Salt, plain, exact _________________	5	5
Amprol plus coccidiostat ___________	.5	.5
Constant premix, exact ____________	2.5	2.5

[1] Unrestricted.

also available for blending with bulk ingredients, such as soybean meal, corn gluten meal, poultry byproduct meal, feathermeal, meat and bone

TABLE 8.—*Examples of broiler starter and finisher rations resulting from linear programing model used*

Item	Starter "E"	Finisher "F"
	Pounds	*Pounds*
Alfalfa meal, 17 percent _________	40	40
Fishmeal, 60 percent ____________	100	160
Poultry byproduct meal, 55 percent_	200	_________
Corn, ground yellow, No. 2 ________	1,050	1,200
Corn gluten meal ________________	100	100
Soybean meal, 50 percent _________	300	340
Poultry oil ______________________	130	130
Dried whey (MNC) _______________	50	_________
dl-Methionine ____________________	.25	_________
Limestone, ground ________________	11	12.5
Salt, plain ______________________	11	10
Amprol plus coccidiostat __________	1	1
Prostrep _________________________	.75	.5
Progen arsanilic acid, 90 grams___	1	1
Constant premix (see table 7)_____	5	5
Total ______________________	2,000.00	2,000.0

scrap, and corn, to make complete feeds. The directions of the manufacturer of the concentrate, superconcentrate, or premix should be followed.

Because premixing is costly and the number of available bins and their capacity are usually limited, the number and unit size of ingredients often must be considered.

Broiler Feeds

Prestarter feeds often are the same as starter feeds, except for one or more additives—generally an antibiotic used at a high level. When some antibiotics are used at a high level in the prestarter, a coccidiostat is not needed. Prestarters are usually fed in mash form.

Starter feeds may be fed as mash, crumbles, or pellets. Birds prefer a medium-coarse feed to a fine-textured one. The grind of the corn in the mash is especially important. The use of crumbles and pellets generally results in enough better growth and feed efficiency and in lower waste to more than offset their cost of production. The breaking down of pellets to crumbles or fines is a major problem with pellets, especially when they are handled in bulk and when the formula is high in fat. The effect of pelleting on the value of the feed is less as the level of the energy, and especially the fat content, of the feed increases.

Broiler finisher feeds are generally lower in protein and higher in fat content than are starters.

Feed Preparation and Distribution

In feed preparation, thorough mixing is important. Technical assistance is often worthwhile in laying out the production unit and in the selection of the equipment for it. Accuracy in measuring and thoroughness in blending are two major considerations.

Broiler feeds are mixed and delivered to the farm in many different ways. A complete feed may be manufactured. This is usually done in a rather large mill, often strategically located as to incoming and outgoing shipments. Many integrated broiler operations manufacture complete feeds. Feeds may be shipped in bulk cars to depots in producing areas, where facilities are available for loading bulk trucks. Another method is to manufacture concentrates in mills and ship them in sacks or bulk to mixing facilities in producing areas, where feeds are mixed to go to the farms in sacks or bulk. The bulk feed is augered or blown into storage bins at the poultry house. Most broiler growers generally use one of these two methods.

A grower may take his grain to a mill to be ground and custom mixed. A concentrate is generally used. It is possible to get on-the-farm mixing units. These usually grind home-grown grain and combine it with a concentrate in one operation. Mobile mills eliminate the costly investment in mixing equipment. They go to the farm, grind and mix feed, and put it into a bin or sacks. The service is sometimes used by the grower who produces and stores his own grain.

The size of the operation and its location, especially in relation to the principal ingredients, and the availability and cost of reliable labor are important in deciding whether complete rations are to be manufactured, concentrates or premixes used in a stationary or mobile mill, or the practice of mixing on the farm is followed. No method is best for all conditions. Most feeds are delivered in bulk from a centrally located mill. The use of bulk trucks has increased with the expansion in the size of broiler enterprises.

Judging Feed Value

When feeds are tagged, a limited amount of information can be obtained from the guaranteed analysis. When feeds are formulated, it is possible to show on paper how close the calculated analysis of the feed compares with the nutritional requirements. A laboratory examination of the feed gives valuable information as to the accuracy of formulation and preparation. No method of calculation or analysis will predetermine the actual nutritional value of a feed. Properly run feeding tests are the best way to arrive at the comparative value of feeds.

If the feeds being compared are fed to one or more separate flocks of broilers, care should be taken to have the flocks of similar breeding and with equal numbers of chickens of each sex. Accurate records should be kept of the mortality, the feed consumed, its cost, the pounds of meat sold, and the total income. With these figures, it is possible to calculate and compare the pounds of feed required to produce a pound of meat, the feed cost of producing a pound of meat, and the income over feed cost. The calculations will assist the feeder in deciding which feed or feed formula is best suited to his purpose.

MARKETING

The price received for the product largely determines whether an operation is successful or not. Supply greatly affects price. To try to anticipate the price, you will need to consider such factors as number of broiler breeders tested, number of breeder pullet replacements (day-old basis), number of eggs set, number of chicks placed, extent of Government buying, and competition of turkeys and other meat products. The number of breeders tested is an indication of what may happen in 12 months; the pullet replacements, 6 or 7 months ahead; eggs set, 3 months; and chicks placed, 9 to 10 weeks. The effect of the first two factors may be influenced if lots of pullets are brought in earlier than usual, the breeder hens are kept longer than usual, and less floor space is allowed per breeder in houses.

The farm price used for settling the grower contract may be based on the quoted price for broilers from the Federal-State Market News Service for the particular area. In the case of the integrated operation, it may depend on what the processor gets when he sells. Price may not be considered in a contract. The trend is away from farm base calculations to ready-to-cook prices.

Marketing Cycle

Normally the demand is a third greater for broilers in June and July than in the fall. The least demand is usually around Thanksgiving and Christmas, when turkeys, roasters, and capons are often preferred. The consumption tends toward smaller broilers in the summer and larger ones in the fall and winter. Most broiler operators recognize the seasonality of demand and plan accordingly. Consideration is being given to freezing some birds in the August-to-December period for sale during the January-to-June period, when the price has been as much as

7 percent higher. Two factors retard this trend —the higher cost of preparing frozen birds and consumer resistance to them. A consumer may buy a chilled bird, take it home, and freeze it, but he resists buying the frozen broilers when chilled icepacked ones are available. Roasters weighing 4 to 8 pounds are shipped in frozen, ready-to-cook condition. The principal markets are New York and Chicago.

Processing, including evisceration, is done now in the areas where the broilers are produced. The ready-to-cook broiler-fryers are icepacked or dry chilled and shipped in fresh form in wholesale quantities by refrigerated trucks to market. The broiler cutting is being shifted from the retailer to the processor, where packs are sized to the specifications of the buyer, marked as to weight, and, if desired, prepriced.

Marketing Areas and Practices

Broilers from Maine are sent to Boston and local New England markets. The rest of the Northeast (Baltimore, Philadelphia, Washington, D.C., New York) is served principally by Delmarva. The midwestern markets used to be supplied from the Delmarva Peninsula. Some of the broilers from the Southeast go to the Northeast, but principally they are trucked to Florida, Atlanta, New Orleans, Dallas, Chicago, Detroit, Cleveland, and Columbus markets. The South Central States, especially Arkansas, Alabama, and Mississippi, ship to Jacksonville, Miami, New Orleans, Dallas, Chicago, St. Louis, Omaha, Salt Lake City, Los Angeles, San Francisco, and Seattle. Broiler production will increase in California, especially if growers there can produce the birds at a low enough cost to compete with the south-central operations and if the returns are at least comparable with other ventures. Most of the Texas production is consumed in Texas.

Frozen export packs have become an important outlet for American-produced broilers. Exporting broilers has the effect of raising prices domestically. Indirectly it increases the demand for materials and services involved in the production of broilers.

It is usual to market broilers at 10 to 11 weeks in the Maine and Delmarva areas and 9 to 9½ weeks in the Southeast. There is no best time. When fixed and chick costs are high and feed costs are low, it usually is more profitable to carry birds longer because there are more pounds over which to spread the fixed costs and the lower feed conversion is not so costly. The processing cost per pound is also less with a heavier bird. The risk, mortality, and increase of breast blisters are factors to consider when birds are kept to heavier weights. When the price is poor, it is often better to market birds as small as the processor will take without cutting the price. In general, broilers should be sold when they reach the normal weight for the processor.

The quality of an individual carcass depends on such factors as the shape or conformation, how well it is fleshed, the amount and distribution of fat, and its freedom from such defects as breast blisters, pinfeathers, disjointed and broken bones, missing parts, discolored skin and flesh, freezer burn, and cuts, tears, and missing skin. Poultry is downgraded if bruising occurs to any extent. Much of the bruising is caused by the way the birds are handled between the farm and the processing plant (see p. 50).

Several management practices will reduce downgrading. A fasting period of 4 hours prior to slaughter is sufficient for the intestinal contents to be reduced to a satisfactory point so that contamination is at a minimum. Give plenty of water as long as possible up to the time of slaughter. Have hanging waterers. Many tears and cuts result from birds flying against inflexible floor waterers. Watch for and eliminate places where birds can roost. Be careful not to scare birds at any time. Use portable wire screens and blue light for catching birds. Have an outside door in each pen. In wide houses, have doors on each side. Remove all feeders, waterers, and other obstructions during loading, as they may cause cuts and bruises.

Flesh bruises are responsible for more than half of the undergrades in most processing plants. Breast bruises are the most common and costly of the injuries. Rough handling by catching crews is the main cause of bruising, including birds hitting partitions and slamming birds into coops. These crews should catch and carry birds by their shanks, not the drumsticks. They should make small drives of about 200 birds and use care in catching and handling the birds.

The assembly operation at the processing plant should be carefully supervised. Coops should not be dropped. Birds should be handled by their shanks. Care should be taken to see that the birds do not hit the wall or any object while on the assembly line. Several investigators have suggested that it might be better to load all birds as needed for processing and run a double shift at the processing plant rather than to load most of the birds at night and process most of them during the day.

The cost of catching and hauling poultry is substantial. It can be reduced by increasing the efficiency of individual farms. An important consideration is the location and size of the farms supplying live birds. An outside door for each pen or several outside doors for each house increase efficiency. Assembly costs per pound decline as the density of the supply area increases. It is advantageous to have larger producing units close to the processing plant. High total volume allows the use of trucks of larger capacity, higher output per man-hour, less overhead, and greater ability to handle larger flocks in a short time. Substantial economies occur in large-scale assembling and processing. However, these are not so important in reducing costs of operation as area density. The expense of a catching crew averages about $3 per 1,000 birds. The transportation cost depends on the distance from the farm to the processing plant. It ranges from one-half to 1 cent per pound of live poultry assembled.

With contract growing and integration, the processing costs have been lowered because plants have been better able to operate at capacity. Less variation has occurred with seasonality of demand and prices.

The method of marketing chickens has improved about as much as production methods. Large processing plants, contract haulers, and contractors have practically replaced the older operation, which included pickups by live-poultry buyers, live-poultry cars, terminal market live-poultry receivers, live-poultry stores, small fattening and dressing plants, and city dressing plants. It is anticipated that a substantial reduction will continue in the number of processing plants and that more combinations of assembling and processing will develop to improve distribution.

More long-term buying contracts by large buyers, such as chain stores, are anticipated. There will also be, to the extent the laws allow, consolidated selling by processors in an area. This may be done by having one selling agency represent several processors. Fluctuating markets could possibly be minimized by contracts based on cost of production plus a reasonable profit. Costs could be minimized if operations could be planned to maximize efficiency with such a program.

Prior to 1927 practically all processed poultry was sold with only the blood and feathers removed. A few plants producing canned poultry and poultry soups had facilities for evisceration. The U.S. Department of Agriculture developed a voluntary inspection program in 1927 as a result of a Canadian regulation, which prohibited the importation of canned poultry products unless accompanied by a certification from the Federal Government attesting that the product had been officially inspected and had been found to be wholesome. New York City enacted a similar regulation in 1928.

The trend toward the sale of ready-to-cook poultry was well underway by 1945. By 1955 the military began purchasing only ready-to-cook poultry, and civilian supplies were almost entirely in this form. Slaughtering and eviscerating operations were generally done in the same plant. Many plants were using the Department's voluntary inspection service. The Poultry Products Inspection Act of 1957, which became fully effective on January 1, 1959, required all poultry moving in interstate or foreign commerce to be inspected. Approximately 90 percent of the poultry sold off farms, including commercial broilers, is federally inspected. The balance of the poultry processed and sold within States may be subject to State inspection.

Poultry is processed and sold within some States on a noninspected basis. The processing plant, and possibly the grading, may be subject to State inspection. It is not unusual for poultry that has not passed or may not pass Federal inspection to be marketed through noninspected channels. Some States now require all processed poultry sold to be federally inspected.

The processors are primarily interested in getting a high percent of eviscerated yield. Condemnations, which are due primarily to air-sac disease and chronic respiratory disease, are the most important factor in reducing yield. Yields are increased by better body conformation and more white meat due to broad breasts. Good yellow skin and flesh and some fat are desired by most processors. Breast blisters and barebacks cause downgrading. Yields are higher in larger birds.

When broilers are processed, there is a strain and a sex difference in the dressing percentage. Cornish broilers and broiler crosses, or strains containing Cornish, give the greatest breast and total edible meat yields. Breast width seems to be the important factor. At the same age, live male broilers are heavier than females, but females give greater eviscerated weights as a percentage of live weight and greater edible meat yields as a percentage of eviscerated weights. The approximate percent of live weight for $3\frac{1}{2}$- to 5-pound birds will be about 87 for New York dressed weight and 73 for eviscerated weight. The edible meat yield as a percent of eviscerated weight will be about 55 for males and 58 for females.

Standards and Grades

The U.S. standards of quality and grades for poultry are used extensively for trading purposes. Many retail distributors require that all ready-to-cook poultry delivered be identified with an official grade mark. Ready-to-cook poultry must have been inspected for wholesomeness to be eligible for grading. Processors applying for resident grading service agree to pay the cost of the service. Graders may be either State or Federal employees. The service is made available at reasonable cost in all parts of the country by means of cooperative agreements with the States. Grade A, B, or C may not be used in connection with labels bearing the official inspection mark unless the poultry has been graded by a licensed grader.

Classes

The official classes of young chickens are as follows:

(1) *Cornish game hen.*—A Cornish, or Rock Cornish, game hen is an immature chicken about 6 weeks old, of not more than 2 pounds ready-to-cook weight. Broiler chickens usually containing some Cornish breeding in the cross are used.

(2) *Broiler or fryer.*—A broiler or fryer is a chicken 8 to 11 weeks old, of either sex, with tender meat and flexible breastbone cartilage.

(3) *Roaster.*—A roaster is a chicken usually 3 to 5 months old, of either sex, with tender meat and breastbone cartilage that is less flexible than that of a broiler or fryer.

(4) *Capon.*—A capon is a surgically unsexed male chicken usually under 8 months old with tender meat.

For details of grading live poultry and more data on the classes and grades of poultry, see U.S. Department of Agriculture Handbook 31, Poultry Grading Manual.

Condemnations

Inspectors in processing plants condemn for disease and other conditions. Of the disease conditions, the respiratory ailments and the leukosis complex are the most important. Condemnations due to respiratory ailments come under the headings of septicemia and toxemia, airsacculitis, and inflammatory processes. For information on the important respiratory diseases—air-sac disease (CRD complex), Newcastle disease, infectious bronchitis, laryngotracheitis, and leukosis—see pages 53–54.

Other conditions resulting in condemnations include bruises due to mishandling during the catching, loading, and transportation of live birds. Also, there are plant-caused condemnations, due primarily to faulty operations, which include cadavers and bruised, contaminated, overscalded, or decomposed birds. Cadavers are largely due to improper bleeding.

The reduction of condemnations is very important to the broiler industry. In 1964, the percent condemned was 2.4, or 193,091,000 pounds (total pounds condemned ÷ (90 percent of pounds inspected — antemortem pounds condemned)). At the average price estimated for 1964 of 14.2 cents per pound, the direct loss was $27,418,922 for the year, not including the loss of efficiency during processing. Condemnations usually cause discounts in grower payments.

The official inspection mark is the consumer's assurance of wholesomeness. One of the primary objectives of this handbook is the production of better birds at lower costs. Reducing condemnations helps materially to do this. For specific suggestions, see page 26.

DISEASES

When a disease outbreak occurs, determine the cause as soon as possible. If you do not recognize the disease or parasite, take or send four or five live chickens to a poultry diagnostic laboratory. Be sure to give the symptoms, number of affected birds, number of deaths, source of stock, size of flock, feeding program, vaccines used, your name, address, and other pertinent information.

It is exceptional to observe tuberculosis, cholera, coryza, blue comb disease, vibrionic hepatitis, botulism, or chiggers and ticks in broilers. Until recently, it was exceptional to find blackhead in broilers.

In broiler production the emphasis is on the prevention of diseases and then, if necessary, on their treatment. Average total mortality to 9½ weeks is considered to be 4 percent. A practical goal is to have only 1 to 2 percent mortality up to 8 weeks. Preparation of the broiler house is discussed on page 20. Other procedures in disease prevention are given on page 26. For detailed information on diseases, refer to Diseases of Poultry.[5]

[5] Biester, H. E., and Schwarte, L. H. diseases of poultry. 1382 pp. The Iowa State Univ. Press, Ames. 1965.

Pullorum and Fowl Typhoid

Most breeder flocks are tested annually for pullorum and typhoid, and eggs are not set from them until all the birds test negative. Bird carriers of fowl typhoid will react to the pullorum antigen. The blood test will not detect birds carrying the infection in the blood stream, only those carrying antibodies. Repeated blood testing is necessary.

In most operations if there should be a breakthrough with either disease, it is possible to trace the ailment to the flock or flocks involved so they can be eliminated immediately as a source of hatching eggs and baby chicks. Furazolidone is the drug most often used in outbreaks.

Omphalitis

This disease is usually caused by contamination of the navel at the time of hatch. To prevent it, only clean eggs should be set and the hatchery, incubators, and hatchers should be kept clean. Fumigation of eggs and incubators with formaldehyde gas is one of the best ways to control this disease. For detailed recommendations on fumigation, see U.S. Department of Agriculture Miscellaneous Publication 739, The National Poultry and Turkey Improvement Plans and Auxiliary Provisions.

Epidemic Tremor (Avian Encephalomyelitis)

This disease appears during the second or third week of life. Chicks have an unsteady walk and then a tremor of the neck and head. There is no treatment for affected chicks. The breeding flock should be immunized by vaccinating at 6 to 8 weeks of age before they pick up the natural infection. Many cases of epidemic tremor are complicated with crazy chick disease. The treatment for the latter should be tried. Survivors of epidemic tremor outbreaks are actively immune.

Crazy Chick Disease (Encephalomalacia)

This disease is usually observed between the third and the eighth week and is characterized by involvement of the nervous system. The onset is sudden. The birds may have convulsions, a retraction of the head, rhythmic spasms of the legs, paralysis, or forced backward movement. On autopsy, pinpoint hemorrhages are found in the cerebellum. Losses can be stopped or reduced by supplying adequate vitamin E in the form of wheat germ oil or tocopherols. A favorable response can also frequently be obtained by suddenly changing the feed, using molasses, or adding alfalfa meal or wheat bran to the feed.

Rickets

Leg weakness and loss of vigor are the early symptoms of rickets. Later the breast becomes crooked and joints become enlarged. The condition is due to an insufficient amount of vitamin D, calcium, or phosphorus or an imbalance of calcium and phosphorus. The ration may be adequate for normal conditions, but not for added stress. Correction of the ration is usually all that is needed.

Curled-Toe Paralysis (Riboflavin Deficiency)

Chicks with this condition usually assume a squatting position. The toes curl inward. Recovery is rapid if the ration is supplemented with riboflavin.

Slipped Tendons (Perosis)

The joints enlarge and then the bones become distorted in perosis. The main tendon over the back of the hock slips to one side. This disorder may be due to an improper balance of calcium and phosphorus or a deficiency of manganese, niacin, choline, or biotin. The dietary deficiency should be corrected. There is no cure for the affected birds.

Nutritional Roup (Vitamin A Deficiency)

Young chicks suffering from vitamin A deficiency usually show a watery discharge from their eyes. Eventually cheesy material collects beneath the lids. Growth is poor, feathers are roughened, and the gait is staggery. The treatment is to provide an adequate vitamin A intake.

Coccidiosis

Coccidiosis is universally present in the chicken. It may affect chickens of any age and is caused by microscopic parasites that infect and damage the cecal pouches, the small intestine, and the rectum. Sick birds are droopy, chill easily, have ruffled feathers, have little or no appetite, and may pass watery or bloody droppings.

A preventive level of drug is the usual method of trying to prevent the disease. In spite of all that has been done, coccidiosis is still a serious problem, due primarily to allowing contamination to build up so the drug cannot handle it at the usual level given.

The sporulation of the cyst stage takes place best at 65° to 85° F. and in the presence of moisture. Transmission is direct as no intermediate host is needed.

Chickens 4 to 6 weeks old are most susceptible to infection, and loss of growth is greatest at this age. A single chicken often has more than one parasite species present.

Cecal Coccidiosis

Bloody droppings is the first symptom of a very acute outbreak of "cecal" coccidiosis. In less acute cases, the birds are dull and droopy, act sleepy, and huddle with ruffled feathers and drooped wings. On postmortem examination, the cecum is greatly distended, filled with blood, and may contain yellowish cheesy cores. The disease is caused by a specific protozoan parasite, *Eimeria tenella*, which lives and causes damage primarily in the cecal pouches.

Intestinal Coccidiosis

Intestinal coccidiosis causes broilers to become weak and thin. The combs are pale. The postmortem lesions are found mostly in the intestines.

Hemorrhages in the intestine are seen in acute cases. When *Eimeria necatrix* is the cause of the trouble, both the ceca and the intestines may be affected. The primary damage is in the small intestine. In severe cases the intestine swells and there is bloody diarrhea.

Another cause of intestinal coccidiosis with symptoms similar to those caused by *E. necatrix*, but often less severe, is *E. maxima*. *E. brunetti* causes damage in both the upper and lower intestines and in the rectum and ceca. Other intestinal species usually of less importance are *E. acervulina*, *E. praecox*, *E. mitis*, and *E. hagani*. Immunity to one species does not produce immunity to another species. Chicken coccidian parasites do not infect turkeys and vice versa.

The prevention of coccidiosis is usually by means of an anticoccidial drug given in the feed when the chick is a day old until as near marketing as possible. Activity of a drug against *E. tenella* and *E. necatrix* is essential. It is desirable also to prevent *E. acervulina*, *E. maxima*, and *E. brunetti*.

To prevent coccidiosis, it is suggested that the following drugs be used in the feed as recommended by the manufacturers: Amprolium, Zoalene, Polystat, or Unistat. To control outbreaks of coccidiosis, it is suggested that one of the sulfonamides—sulfaquinoxaline, sulfamethazine (Sulmet), or sulfathiazole—Zoalene, or Amprolium be used at the levels recommended by the manufacturers.

Nonspecific Enteritis

This condition is common in young birds and is often confused with intestinal coccidiosis. It is possibly related to the hemorrhagic anemia syndrome and gizzard erosion. To differentiate it from coccidiosis, oöcysts will not be present, it does not respond as well to sulfonamides as does coccidiosis, and nonspecific enteritis usually persists much longer—many days or weeks. Signs include listlessness, loss of appetite, and diarrhea. Lesions consist of the inflammatory condition of the intestinal tract. This disease can be the result of wet litter, overheating, chilling, faulty feeding, and dirty waterers.

"Red spot" disease (red spots often seen in the intestine) may be nonspecific or it may be due to one or more species of coccidia (*Eimeria mitis*, *E. maxima*, or *E. necatrix*). If coccidia are not found, the directions for using the feed-grade antibiotic, or a nitrofuran compound if tried, should be followed. Nonspecific enteritis does not respond well to any treatment. Good management seems to be a good preventive and control measure.

Avian Nephrosis (Gumboro Disease)

Usually avian nephrosis attacks chicks between 21 and 28 days of age. They are depressed and sometimes tremble. They show little interest in feed and water. They stagger, fall down, and die. The active period of mortality is 7 to 8 days, but it varies. It peaks halfway through this period. On postmortem, the kidneys are pale or gray, the bursa is enlarged, and usually hemorrhages are in the muscles of the legs, thighs, and breast. There is no way to prevent or cure this disease. Once it is on a farm, it usually persists. Removing the litter, treating the floor with lye, and spraying the house with a synthetic phenolic disinfectant may help.

Hemorrhagic Anemia Syndrome

Affected flocks do not eat, become weak, squat on their hocks, and show the typically pale or dark combs. On postmortem, irregular, scattered hemorrhages are found in the muscles of the breast, the outer part of the thigh, and the internal organs. The blood is usually pale and slow to clot. The bone marrow may be yellow or gray instead of normal red. The kidneys are pale and swollen. Broilers 3 weeks old to market age may be affected.

There is no known causative agent. Several of the aspergilli may be implicated. Vitamin E and K deficiencies and moldy-feed toxicosis will produce similar signs. Other possible predisposing factors are excessive medication and the stress of diseases, particularly avian nephrosis (Gumboro disease). Sulfonamides (sulfaquinoxaline, sulfamethazine, or sulfathiazole) seem to aggravate the condition. This syndrome may be associated with nonspecific enteritis and gizzard erosion. It may help to increase the vitamin K intake and give codfish liver solubles, condensed fish solubles, and trace minerals. An effort is being made to find and eliminate the cause.

Gizzard Erosion

Gizzard erosion is characterized by small hemorrhages under the horny layer of the gizzard, causing it to darken and erode. It is often associated with nonspecific enteritis and the hemorrhagic anemia syndrome. The condition is found in less vigorous birds and it does not respond to treatment.

Moldy-Feed Toxicosis

Many strains of fungi have been isolated from broiler mash and from substances toxic to poultry. Chickens become depressed, develop diarrhea, have pale comb and wattles, and on postmortem show a hemorrhagic condition, gizzard erosion, and a necrotic condition of the liver.

When litter becomes damp, especially around the waterers, the molding process starts and grows within 10 days. It spreads to other damp areas in the litter. Any feed scattered in the litter serves as a means for the fungi to increase and toxins to be produced. Chickens that ingest infected feed or litter invariably develop a toxicosis. How serious it is depends on the type of fungi, the potency and amount of toxin, and the period of ingestion. Toxicosis usually reaches its peak when chickens are 4 to 6 weeks of age. It is not known why molds gain or lose toxicity.

Aspergillosis

Infection is usually caused by rearing chicks on moldy litter or on litter that has been moldy prior to use. Feed occasionally is at fault. The birds usually have some difficulty breathing. There are nodules and abscesses in the lungs and yellow exudate is in the air sacs. There is no treatment for affected birds. The litter should be changed. This will prevent additional birds from becoming infected.

Leukosis and Marek's Disease

Avian leukosis and Marek's disease are characterized primarily by an independent rapid succession of divisions of essential blood-forming cells. Marek's disease has commonly been referred to as neural and ocular lymphomatosis. The neural form includes fowl and range paralysis and the ocular form, blindness and gray, glassy eyes. The disease does not react to the tests currently used for leukosis detection. Leukosis includes visceral lymphomatosis, osteopetrosis, erythroblastosis, myeloblastosis, myelocytomatosis, and nephroblastoma. Visceral lymphomatosis is characterized by an enlarged liver. It may parallel the neural and ocular forms. In the visceral form, any organ may be affected. The skin may have small tumors in the feather follicles or large skin tumors. Osteopetrosis, the thick-leg disease, occurs more in male than in female broilers. The condition often escapes detection until the birds are dressed and may be sporadic in nature. The other forms of leukosis do not usually occur in broilers.

The indicated preventive and control measures are breeding for resistance, hatchery sanitation, thorough cleansing and disinfection of brooder houses and equipment, a reasonable break between broods, and isolation of young from adult stock. Parasites should be kept under control.

For further information, see U.S. Department of Agriculture Production Research Report 94, An Outline of the Diseases of the Avian Leukosis Complex.

Infectious Bronchitis

The disease comes on suddenly and spreads rapidly with a high proportion of the chicks becoming ill. The mortality is usually less than 10 percent, but may reach 70 percent in chicks under 4 to 5 weeks and less in older chickens. In broilers the major damage of infectious bronchitis is the stress effect in bringing on airsac disease. The symptoms include nasal discharge, watery eyes, depression, coughing, and gasping. Bronchitis is often followed within 7 to 10 days by an attack of chronic respiratory disease (CRD), which is usually far more serious. A laboratory diagnosis is necessary, as bronchitis cannot be differentiated from other respiratory diseases on the basis of lesions alone. A preventive and control program will depend on local conditions. It may include vaccination.

Newcastle Disease (Pneumoencephalitis)

The respiratory symptoms of Newcastle disease are similar to those described for bronchitis, but are usually more severe. Mortality can be negligible or near 100 percent in 10 to 14 days, but mostly in 2 or 3 days. Following recovery, nervous manifestations may or may not occur, such as walking in circles, paralysis, twisted neck, and somersaulting. They do not occur with bronchitis. CRD may follow Newcastle disease in 5 to 7 days. As in bronchitis, lesions are not diagnostic. There is danger of spreading the disease by crates, trucks, litter, and tracking. Security management is recommended. In congested broiler areas preventive vaccination is practiced extensively.

Laryngotracheitis

In acute laryngotracheitis, the respiratory symptoms are severe—gasping and coughing. The intake of air is accompanied by loud wheezing. In less severe attacks, the symptoms may be those of a cold. The incidence of the disease is much less than that of either infectious bronchitis or Newcastle disease, and its spread is slower. It rarely is observed in broilers less than 4 weeks old. It is highly contagious. It is airborne over short distances and is transmitted by persons, trucks, dogs, crows, or other agents. It is a carrier disease. Some of the recovered birds continue to carry the virus and to be infectious to susceptible birds. An accurate diagnosis can only be done on the basis of laboratory procedures.

Birds should not be vaccinated unless the disease is known to be in the area. If it is diagnosed in the flock, all groups not affected should be vaccinated. Mortality varies from below 10 to as high as 50 percent.

Colibacillosis (*E. coli* Infections)

Escherichia coli infections in broilers may take the form of an enteritis or an air-sac infection. Trouble may start with infected hatching eggs. Apparently clean eggs packed in used dirty cases may be contaminated by this contact. Coliform bacteria are often associated with a pleuropneumonialike organism (PPLO) in air-sac disease. Pathogenic *E. coli* infections may be triggered at 5 to 8 weeks by stress, live-virus vaccinations, respiratory viruses, coccidiosis, roundworms, and poor environmental sanitation and management practices; for example, overcrowding, poor ventilation, excessive humidity, too much dust, and temperature extremes. The birds may have ruffled feathers, may be droopy, and have diarrhea. If the air sacs are infected, severe depression, coughing, and other symptoms similar to CRD are evident. A laboratory examination is needed to diagnose this disease.

To prevent and control coliform enteritis, furazolidone and the antibiotics—Aureomycin, Terramycin, streptomycin, erythromycin (Gallimycin), neomycin, and tylosin (Tylan)—are used. *E. coli* infections may readily develop resistance to certain antibiotics.

Chronic Respiratory Disease

Chronic respiratory disease (CRD), avian mycoplasmosis, or air-sac disease is the leading cause of condemnations at the dressing plant. It also causes a great loss in weight and mortality. In the field it is a disease from which many infectious agents may be isolated. The primary cause of the infection is a pleuropneumonialike organism (PPLO). CRD in an uncomplicated respiratory infection is caused by a PPLO identified as a *Mycoplasma.* When a secondary infection is added, the disease becomes complicated and lesions may be moderate to severe in form. If the secondary infection is bacterium *E. coli*, more than one bacterium, or fungi, the symptoms are usually severe.

The combination of PPLO and the viruses of infectious bronchitis and Newcastle disease, either naturally or by vaccination, causes respiratory symptoms and air-sac lesions. This multiple infection found in the field is the CRD complex often called air-sac disease. The symptoms and lesions are most severe when produced by combining PPLO, *E. coli*, and the viruses of infectious bronchitis and Newcastle disease. Either infectious bronchitis or Newcastle disease, when combined with PPLO and *E. coli*, causes a severe form of CRD. Good management helps reduce the effects of *E. coli* especially.

Adverse environmental conditions will intensify the severity of the disease. The chicks may be weak, may be handled roughly, or be overheated or chilled at the hatchery or on the way to the brooder house. In the brooder house, they may be overheated, chilled, overcrowded, have insufficient feed or water space, inadequate ventilation, too high humidity, and damp or wet litter. The most important stress is probably outbreaks of diseases, such as coccidiosis, Newcastle disease, infectious bronchitis, laryngotracheitis, or the reaction to vaccination for Newcastle disease and infectious bronchitis.

CRD is an egg-transmitted disease. The rate of transmission from breeder flock to baby chicks is thought to be about 10 percent, but varies greatly. PPLO stock negative to S_6-type *Mycoplasma* antigen is being produced. This stock is negative only to S_6-type antigen, not necessarily to others, such as pathogenic Iowa strains 0 and 695.

The incidence of CRD complex has been materially reduced where PPLO-free chicks have been used to produce broilers. By using antibiotics it is possible to medicate the chicks and destroy the *Mycoplasma* originating from embryonic sources. The breeder replacement chicks are injected and fed a potentiated high-level antibiotic feed. They are then raised under a management-sanitation-security program to keep them free of CRD. They must be protected from reinfection. Strict attention to isolation and sanitation is essential.

The breeders so produced may be used to produce PPLO-free chicks. These chicks should not be mixed with other chicks or exposed to PPLO infection. In experiments being conducted to develop mycoplasma-free progeny, primary breeder and replacement flocks are exposed to a pathogenic strain of *Mycoplasma* at 5 to 9 weeks of age.

The control of CRD complex, other than eliminating PPLO from the breeder flock, in the field also consists of attempting to suppress the *E. coli* and other bacterial contaminants with chemotherapeutic agents. Furazolidone has been extensively used. The antibiotics commonly used are Aureomycin, Terramycin, streptomycin, erythromycin (Gallimycin), neomycin, and tylosin (Tylan). The first objective is to suppress or eliminate PPLO. This has been done with potentiated Aureomycin and other antibiotic agents. Locally it is sometimes practical to eliminate Newcastle disease and infectious bronchitis vaccinations, but often impractical and unattainable. Careful vaccination and antibiotic therapy help to keep broilers growing while the birds still carry PPLO. The security management program (p. 26) should be followed.

Synovitis
(Infectious Synovitis)

Synovitis also causes heavy losses. Considerable economic loss is due to birds getting thin and downgrading at market time. Infectious synovitis is caused by *Mycoplasma synoviae*, *M. gallisepticum*, and an unnamed arthritic-producing agent.

The birds first become droopy and listless. Their legs are weak. Lameness is observed. When handled, the hocks show enlargement. The swollen joints and footpads are painful and discourage the birds from eating; consequently, they soon lose weight. They huddle, as if cold. Mortality does not usually exceed 5 percent. Birds are generally 5 to 7 weeks old when first affected. In later stages of the disease the comb dries up, the feathers become ruffled, and the droppings are green with an excess of white material, or urates. On postmortem examination, a yellowish fluid is found in the bursae and joints. As the disease becomes more severe, a cheeselike substance is present in the bursae and tendon sheaths. The joints of the wings and shoulders and also the sternal bursa may be affected.

The most effective treatment is to cull affected birds and treat the rest with 200 grams of Aureomycin or 100 grams each of Aureomycin and nf-180 (furazolidone) per ton in the feed continuously until 3 days before marketing. When the disease is expected, 50 grams of antibiotic per ton of feed can be given to the birds continuously from 1 day old. This is not adequate if other infections, such as CRD, are a stress. There is no cheap way of preventing synovitis or of handling an outbreak of this disease.

Fowl Pox

Fowl pox is caused by a virus and is sometimes found in broilers in certain areas of the South, especially during the mosquito season in the late summer and fall. The typical lesions occur on the unfeathered parts of the body. The head is principally affected. The infection may involve the mouth, nasal chambers, and eyes. Dry pox is usually easily identified by the typical wartlike growth on the comb, wattles, or face. In broilers, eye infection is most common. When pox infects the mouth and nasal passages, respiratory symptoms may be exhibited and birds may suffocate. This form is called wet pox.

Routine vaccination of broilers may be advisable where fowl pox occurs regularly. Fowl pox vaccine is preferred, using the wing-web method and only one needle, when the birds have been in the broiler house for 7 to 10 days.

Vaccination

The program for vaccination should depend on local conditions. In most concentrated broiler areas, it is cheap insurance against heavy losses.

Vaccines should be used according to the instructions of the manufacturer regarding time and method. They should be kept cool before being opened and used immediately after they are opened. Sometimes broilers are vaccinated and yet an outbreak of disease occurs. In most cases, the cause is not following the directions enclosed with the vaccine.

Vaccination, especially for Newcastle disease, has often been done when the chick is a day old. Superior results can be obtained if Newcastle disease vaccine is given when chicks are 7 to 10 days old. Except in isolated areas, a booster, or second vaccination, is given in the water at 4½ to 5 weeks. Infectious bronchitis vaccination, if used, should be given 7 to 10 days after the Newcastle vaccination.

Live-virus vaccines are used against fowl pox, infectious bronchitis, laryngotracheitis, and Newcastle disease. For Newcastle disease, killed-virus vaccines are also available. A killed-virus vaccine cannot cause the disease and is therefore safer to use and is most useful for broilers, because there is less stress for CRD and it does not spread live-virus infection. However, it may have the disadvantages of increased labor cost due to having to be injected, the danger of vaccination crews spreading disease, the higher cost of the vaccine, and the short duration of immunity.

The methods of vaccination include the *wing-web*, which is used for administering one type of Newcastle vaccine; the *intraocular*, in which the vaccine is applied with a dropper in the eye or nostril of the bird, and is used by some poultrymen for Newcastle vaccination at 5 to 10 days of age; and mass immunization methods. Vaccine is applied with a garden duster in the *dust method* for Newcastle vaccination. A hand or machine sprayer is used to apply the vaccine as a fine mist in the *spray method*. The easiest way with the least reaction is the *water method*, also used for administering Newcastle vaccine, especially boosters. It is used sometimes for bronchitis vaccination. Fowl pox vaccine is usually applied when the chick is 7 to 10 days old, using one prong in the web of the wing.

No vaccination program is entirely successful without strict management practices to limit possible spread of infection. Growers should not visit other flocks. The first 4 weeks of a chick's life should be in isolation. Servicemen should visit flocks less than 4 weeks old the first thing in the morning, and they should not enter the house unless absolutely necessary. They should start out each day with clean outer clothing. The use of disinfected boots or clean plastic shoe covers in broiler houses is essential. A change in clothing should be made after visiting any farm where there is an outbreak of respiratory ailment. When outbreaks of respiratory disease occur, the disease usually has been introduced by a human carrier.

Other Conditions Causing Disease and Mortality

Barebacks and Cannibalism

Feather pulling and picking can cause considerable loss from downgrading to mortality. Anything that makes the chicken uncomfortable will lead to feather pulling. If feather pulling is not controlled, picking may cause barebacks and lead to cannibalism and deaths. Breeding may be a factor. Slowness of feathering combined with poor management encourages the vice. Some strains are less cannibalistic than others.

Check faulty management practices. These include too high a temperature or humidity, lack of fresh air, drafts, overcrowding, infestations of worms, lice, or mites, lack of feed or water, insufficient feed or watering space, and excessive light including sun spots. More feather picking occurs with pellet and crumble feeding than with mash feeding because the birds have more time to develop vices. To avoid feather picking, debeak the birds properly and do everything possible to make them comfortable. Debeaking and providing adequate floor, feed, and watering space are discussed under Brooding (pp. 21–23). When feasible, remove injured birds and treat with an antipick preparation. Other control measures include cooling the house (p. 19), scattering whole oats in the litter, or adding 2 pounds per ton of fine salt to the mash for 2 days.

Mites, Lice, and Ticks

Mites, lice, and ticks are common external parasites of chickens. They cause stress, lack of vigor, and mortality. For information on the control of these pests, see the following U.S. Department of Agriculture publications: Leaflet 382, The Fowl Tick—How To Control It; Leaflet 383, Poultry Mites—How To Control Them; and Leaflet 474, Chicken Lice—How To Control Them.

Rats and Mice

Rats and mice kill young chickens, destroy eggs, eat or contaminate poultry feed, and damage buildings by gnawing wooden walls, foundations, and equipment. They also spread many diseases and parasites.

Losses from rats and mice in a commercial broiler flock may total several hundred dollars a year, including chickens, feed, and other destruction. The damage often goes unnoticed, because losses are gradual and because rats and mice seldom appear when anyone is in the poultry house.

To make new buildings rodentproof, use concrete foundations and floors. Metal shields around doors and hardware cloth over openings are effective in keeping rodents out of buildings.

Shelter is second only to food in the rodents' requirement for survival. Control rats and mice with poison before you attempt to destroy their breeding and hiding places. Once the rodent population is under control, dispose of trash dumps, piles of old lumber or manure, and garbage. Find and block runs or burrows.

Mix poison in baits with cereal, ground meat, or fish, or sprinkle poison baits on fruits and vegetables. Place bait along well-traveled runs and near centers of activity. When using any poison, protect poultry and domestic animals from accidental poisoning by carefully placing baits in protected stations. After the existing infestation has been eliminated, maintain poison stations at all buildings and trouble spots. Check stations regularly, and keep a supply of fresh bait exposed to eliminate new invaders.

Anticoagulant poisons are slow acting and require 5 to 14 days to exterminate rats and 10 to 30 days for mice. For information on fast acting poisons or other control methods, consult your county agricultural agent.

Caution: All poisons are dangerous and can kill small animals and pets if used carelessly. Anticoagulant rat poisons—warfarin, pival, fumarin, and Diphacinone—are safe when used according to the manufacturer's instructions. They may be purchased as powdered concentrates for dry baits or in water-soluble form.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1967 —O 223-122

MANAGEMENT GUIDE

Family Unit Size.—45,000 broilers.

Labor.—With automatic feeders, not over 18 minutes per 1,000 per day; without automatic equipment, not to exceed 31 minutes.

House-Unit Size.—7,200 to 20,000 per house; desirable size is 15,000 in 40- by 300-foot house.

Pen Size.—1,200 to 2,500 per pen.

Floor Space.—0.8 square foot per 3- to 3.75-pound broiler; 1 square foot for summer-reared and per 4-pound bird and over.

Brooder Space.—750 to 1,000 chicks per 1,000-chick size hover; varies with season, insulation, and mechanical ventilation.

Litter.—2 to 4 inches—less in hot weather.

Fountains.—1-gallon fountain per 100 chicks to 2 weeks old.

Water Space.—Three 8-foot automatic waterers per 1,000; add one more per 1,000 birds when temperature is 90° F. or higher.

Feeder Lids.—One feeder lid per 100 chicks.

Feeder Space.—Allow fifteen 15-inch diameter 30-pound capacity hanging feeders per 1,000; allow 1 linear foot per 12 broilers for mechanical feeders.

Feedings.—Follow directions of feed manufacturer or formulator.

Lights.—After 2 weeks, use all-night lights; one 25-watt bulb per 100-square foot floor space.

Security Management.—Follow good management practices as far as is economically feasible. (See inside front cover and Security Management, p. 26.)