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Nutritive Requirements and Feed Formulas for Chickens

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INTRODUCTION

Poultry nutrition has come a long way since the days when the farm flock was fed largely on table scraps supplemented with whatever the birds could pick up around the farmyard in summer and a few handfuls of corn or other grain daily during the winter. Profitable flocks today are fed on carefully prepared feed mixtures, and the quantities consumed are enormous.

It is estimated that the chickens of the United States consume in a year more than 20,000,000 tons of feed. This is at least one-sixth of all the concentrate feeds supplied to livestock. It also represents about one-half of the total cost of producing eggs and poultry meat in the United States. These figures emphasize the importance of the proper use of poultry feed to the efficiency of our agriculture, and especially to the efficiency of the poultry industry.

The best possible use of feed by chickens would occur only if all the required nutrients were present in exactly the proportions needed.

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Although present knowledge is not sufficient to permit reaching this goal, the quantities of 10 vitamins, 9 minerals, and 6 amino acids needed by growing chickens can be stated with some assurance.

HOW CHICKENS USE THEIR FEED

The greater part, but not all, of the feed eaten by chickens serves as building material or as fuel. First, it goes into the digestive tract, where it is soaked, ground, and mixed with digestive juices, which promote chemical changes in the feed and convert it into materials that can pass through the wall of the intestine and be carried in the blood stream to all parts of the body.

The principal structural materials in a chicken are proteins, fats, calcium phosphate, and water. All of these are derived from the diet; the proteins from the proteins of the feed, which are first broken down and then reassembled, the fats from the carbohydrates, fats, and proteins of the diet; and the calcium phosphate from the calcium salts and phosphate of the feed. The principal structural materials of an egg are the same as those for the bird, except that calcium carbonate replaces calcium phosphate.

Chickens require fuel to provide heat to maintain body temperature, and to provide energy for muscular activities and life processes. Carbohydrates, fats, and proteins are the fuels "burned" by the chicken. They are burned by special chemical reactions which are regulated by substances known as enzymes and hormones. The chicken produces these only if the diet provides the essential raw materials, among which are the vitamins and trace minerals. Taken all together, these raw materials make up only a very small fraction of the diet; yet every one of them must be present in sufficient quantity if the chicken is to live, grow, and reproduce normally.

NUTRIENTS REQUIRED BY CHICKENS

Much attention has been given to determining the quantities of the various nutrients required by chickens. The information summarized in table 1 and in the tabulation on page 3 was prepared by a committee of the National Research Council.[1] Table 1 gives recommended nutrient allowances for protein and for several vitamins and minerals. The recommended allowances of vitamins are higher than the actual requirements; 66 percent higher for vitamin A, 50 percent higher for vitamin D, and 20 percent for the others. The margins compensate for partial loss of vitamins during storage of feed.

[1] RECOMMENDED NUTRIENT ALLOWANCES FOR DOMESTIC ANIMALS, No. 1. RECOMMENDED NUTRIENT ALLOWANCES FOR POULTRY. National Research Council, Washington 25, D. C., June 1944 (rev. Nov. 1, 1946. Processed).

TABLE 1.—*Recommended nutrient allowances for chickens* [1]

Nutrient	Amount per pound of feed for—			
	Starting chicks, 0–8 weeks old	Growing chicks, 8-18 weeks old	Laying hens	Breeding hens
Total protein—percent	20	16	15	15
Vitamins:				
Vitamin A activity—I. U [2]	2, 000. 0	2, 000. 0	3, 300. 0	3, 300. 0
Vitamin D—A. O. A. C. units [3]	180. 0	180. 0	450. 0	450. 0
Thiamine—milligrams	. 9	([4])		
Riboflavin—do	1. 6	. 9	. 9	1. 3
Pantothenic acid—do	5. 0		2. 5	5. 0
Nicotinic acid—do	8. 0			
Pyridoxine—do	1. 6		1. 6	1. 6
Biotin—do	. 045			. 07
Choline—do	700. 0			
Minerals:				
Calcium—percent	1. 0	1. 0	[5] 2. 25	[5] 2. 25
Phosphorus [6]—do	. 6	. 6	. 75	. 75
Salt—do	. 5	. 5	. 50	. 50
Manganese—milligrams	25. 0			15. 00
Iodine—do	. 5	. 5	. 50	. 50

[1] See footnote 1, p. 2.
[2] May be fish oil vitamin A or provitamin A from vegetable sources. I. U., International Units.
[3] This is the official unit of the Association of Official Agricultural Chemists.
[4] Blank spaces indicate that requirements are unknown.
[5] This amount of calcium need not be incorporated in the mixed feed inasmuch as calcium supplements fed free choice are considered as part of the ration.
[6] Inorganic phosphorus should constitute 0.2 percent of the total feed.

The tentative requirements of growing chickens, up to 8 weeks of age, for certain amino acids and minerals, and for vitamin K are as follows:

Nutrient: Amino acids	*Amount per pound of feed*
Glycine—percent	1. 0
Arginine—do	1. 0
Methionine, or—do	. 9
(Methionine)—do	. 5
(Cystine)—do	. 4
Lysine—do	. 9
Tryptophane—do	. 25

Nutrient—Continued Vitamin:	*Amount per pound of feed*
Vitamin K—milligram	0. 18
Minerals:	
Potassium—gram	. 8
Magnesium—milligrams	180. 0
Iron—do	9. 0
Copper—do	. 9

These figures are based on more limited evidence than are those in table 1.

CARBOHYDRATES AND FATS

The tables do not state the requirements for carbohydrate and for fat, because these nutrients serve primarily as fuels and, therefore, each can be replaced at least partly by the other or by protein. Among the items usually found in tables of analyses of feeds and feedstuffs

are fat, crude fiber, and nitrogen-free extract. The last two consist chiefly of carbohydrate, but the distinction between them is important because the carbohydrates of the nitrogen-free extract are chiefly starches and sugars which are well utilized by chickens, whereas the carbohydrate of the crude fiber is chiefly cellulose, which is utilized by chickens only to a very limited extent.

The grains and their byproducts are the principal sources of carbohydrates in poultry diets. Fats occur in practically all of the commonly used feedstuffs except the minerals.

Protein

Protein makes up about 20 percent of the body of the chicken and nearly 14 percent of the contents of the egg.

According to experiments conducted at the Agricultural Research Center, Beltsville, Md., the best level of protein for growing chickens is 21 percent of the diet. It is usually more economical, however, to reduce the level of protein as the chickens become older, as indicated in table 1. The requirement of laying birds is lower than that of growing chickens.

As protein supplements are among the more expensive feed ingredients there is a temptation to reduce the quantities used below the recommended levels. Such a procedure reduces the efficiency of feed utilization for growth and egg production and is likely to prove false economy. If carried far enough it reduces rate as well as efficiency of growth and egg production.

The kind of protein is fully as important as the quantity. Proteins are built up of units known as amino acids. There are about 20 different amino acids occurring in proteins and the proportion of these in the proteins of the chicken and of the egg are fixed and unchangeable. The chicken can manufacture some of these amino acids but not others which obviously must be present in adequate quantities in the proteins of the feed.

The idea has been generally accepted that feed proteins of animal origin contain more of the essential amino acids than do proteins of plants and, therefore, are better. However, it has been demonstrated recently at the Agricultural Research Center that soybean meal is as satisfactory a source of protein for chickens as are the animal products, provided the diet contains an unknown vitamin-like substance which occurs in fish meal, dried skim milk, and in the manure of cattle and of chickens.

Minerals and Grit

The body of the chicken contains nearly 4 percent of mineral material; and the egg, including the shell, contains about 10 percent.

The recommended allowances of calcium, phosphorus, salt (sodium chloride), manganese, and iodine are given in table 1. These are the minerals that ordinarily have to be supplied as mineral supplements. In addition, chickens are known to require potassium, magnesium, sulfur, iron, and copper; but these are furnished in sufficient abundance by the grains and other ordinary constituents of feeds and do not have

to be added in the form of mineral supplements. The requirements of growing chickens for some of these elements are given in the tabulation on page 3.

It is important to be sure not only that the quantities of calcium and phosphorus in the diet are sufficient, but also that the correct ratio is maintained between them, since too much of either will decrease the availability of the other. A deficiency of either of these elements interferes with growth and bone development in the young chicken and with egg production in the mature bird. The calcium requirement of the laying hen is high because the eggshell is composed almost entirely of calcium carbonate and if the supply of calcium fails, the hen produces eggs with thin shells or no eggs at all. Thin-shelled eggs may also result from a deficiency of vitamin D or from too high environmental temperatures. Pullets in the first few weeks of egg production often lay some eggs with no shells at all. This situation cannot be corrected by changing the diet but it usually corrects itself in the course of time.

The principal sources of calcium in feeds for chickens are oystershell and high-calcium limestone. Both calcium and phosphorus are supplied by bonemeal and defluorinated calcium phosphates and to a lesser extent by meat meal and fish meal. The naturally occurring calcium-phosphate rock should not be fed; it contains too much fluorine. Phosphorus is furnished in smaller quantities and in a less available form by the vegetable-protein supplements, grains, and grain by-products.

Of the feedstuffs commonly fed to poultry, fish meal is the only one that contains much salt, therefore salt is usually added to mashes. Lack of it interferes with growth and with egg production and may lead to cannibalism.

Manganese is present in nearly all the ingredients of poultry feeds, but not in sufficient quantity to insure an adequate supply. Lack of manganese causes perosis (slipped tendon) in growing chickens. Low hatchability results if the diet of breeding birds is deficient in manganese. The embryos that fail to hatch are characterized by short bones in the legs and wings and by "parrot-beak."

Manganese can easily be added to mashes in the form of "manganized" salt, prepared by mixing 100 pounds of table salt and 3 pounds of anhydrous manganous sulfate (or 4.5 pounds of manganous sulfate tetrahydrate).

The iodine content of feedstuffs is variable, and in the North-Central States, it is low because of a deficiency of iodine in the soil. Insufficient iodine leads to goiter (enlargement of the thyroid gland) in chickens as in other animals, although this condition appears to be less harmful to chickens than to man and the common farm mammals. Commercial iodized salt is ordinarily used in poultry feeds in the deficient areas.

Chickens on range may be expected to get all the grit they need; but if they are confined without access to the soil, grit should be supplied to them. Native pebbles and river gravel are best for this purpose, but if these are not readily available, any hard rock which is not easily shattered may be used.

Vitamins

As in the case of minerals, there are some vitamins which are always supplied abundantly by the ordinary ingredients of poultry feeds and so need not be matters of concern to the poultryman. There are others, notably vitamins A and D and riboflavin, which are often inadequately supplied.

The function of vitamin A is not well understood but a deficiency of this vitamin results in several well-known symptoms. Affected young chickens grow slowly, develop a staggering gait, and may lose the ability to stand or walk. Mature birds show a decrease in egg production and then stop laying. Later a white, cheesy material appears in the eyes and in the throat. This condition has been called

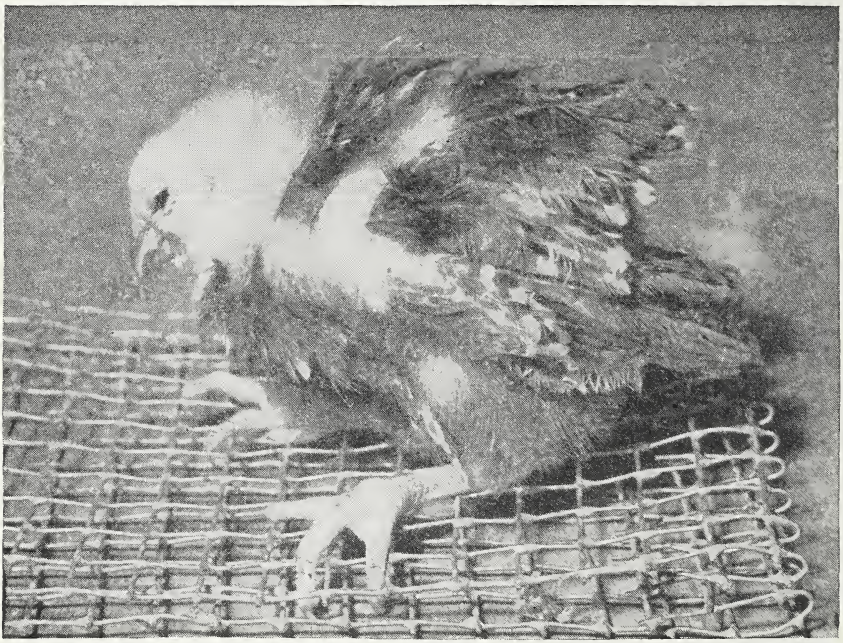

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Figure 1.—Young chick showing effects of vitamin D deficiency. Note the crossed beak, which is soft and rubbery, and bird's inability to stand.

nutritional roup because of its resemblance to infectious roup. Continued deficiency results in death. Certain fish oils and fish-liver oils are excellent sources of vitamin A and are widely used in poultry feeds. Chickens are also able to convert into vitamin A several closely related compounds that occur in green feed, yellow corn, corn-gluten meal, and carrots.

Vitamin D is essential for the normal utilization of calcium and phosphorus. When it is not supplied in sufficient quantity, young chickens grow slowly and develop soft bones (fig. 1); laying hens first produce thin-shelled eggs and then stop laying. This vitamin is not widely distributed, and almost any diet for chickens is likely to be

deficient unless it contains a special source of vitamin D. The principal sources are fish oils and activated animal sterol. When chickens are exposed to direct sunlight, vitamin D is formed in the skin and can be utilized by the bird. For this reason, growing diets for birds on range frequently contain no vitamin D. Because of the high requirement of laying hens, some vitamin D is usually included in their diet even if they are exposed to sunlight.

Riboflavin (also called vitamin G), unlike vitamins A and D, is needed in greater quantities by young chicks than by laying hens. The requirement per unit of feed decreases as growing chickens become older. More riboflavin is needed for the production of hatching eggs than for the production of market eggs because this vitamin is very

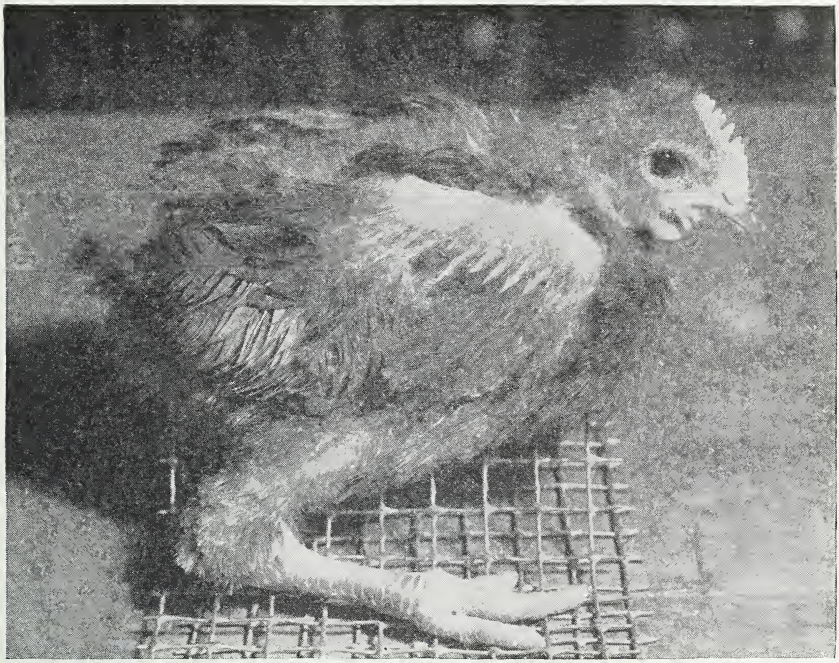

FIGURE 2.—Young chicken showing symptoms of riboflavin deficiency. Note the curled toes and tendency for the bird to rest its weight on the hocks.

important in the development of the embryo. Deficiency of riboflavin in the diet of young chicks leads to poor growth and to so-called curled-toe paralysis (fig. 2). Deficiency in the diet of breeders leads to low hatchability. The embryos that fail to hatch are characterized by small size and by a defect of the down known as "clubbed" down. Riboflavin is widely distributed in feedstuffs and is also available as a synthetic compound. Among the best natural sources are dried-milk products and fermentation byproducts. Moderately good sources are alfalfa meal, fish meal, and meat meal.

Thiamine, nicotinic acid, pyridoxin, and vitamin K, like riboflavin, are known to function in certain enzyme systems. The functions of biotin and pantothenic acid are not well understood. Choline is an essential part of certain important organic compounds that occur in all

living matter. Unlike riboflavin, these vitamins are supplied in sufficient abundance by grains, grain byproducts, and oilseed meals so that there is little likelihood of deficiency in practical diets for chickens. Deficiency of thiamine or pyridoxin interferes with the normal functioning of the nervous system. Lack of nicotinic acid causes "black-tongue" and perosis (slipped tendon). Lack of vitamin K interferes with the clotting of the blood. Scabby incrustations around the mouth and on the feet result from a lack of either pantothenic acid or biotin, and perosis results from a lack of either biotin or choline.

In addition to the vitamins mentioned in tables 1 and 2, chickens need vitamin E for normal development of the nervous system and for normal reproduction and pteroyl glutamic acid (folic acid) for normal blood formation. For the latter function it has been reported that another factor, pyracin, is required in addition to pteroyl glutamic acid. Vitamin E is supplied by grains and other seeds but is easily destroyed during the storage of feed; and as a result of vitamin E deficiency, encephalomalacia or "crazy-chick disease" is sometimes observed in growing chickens. It is characterized by loss of control of the muscles, especially of the neck and legs.

Chickens also require several other vitaminlike factors which are known thus far only by the response of the chicken to their presence or absence. At least one of these, the factor needed for the proper utilization of soybean meal and perhaps of other proteins is of practical importance. This factor has been mentioned previously in the discussion of proteins.

Water

As water makes up about two-thirds of the weight of the whole egg, including shell, and about half the weight of a mature chicken, it is obviously important to supply plenty of water to chickens at all times. Chickens consume about twice as many pounds of water as of feed. About 6 gallons of water is required per 100 laying hens per day. The water requirement per 100 chickens per day is about 1 gallon during the first 2 weeks after hatching, 1.5 to 2 gallons between the ages of 2 and 6 weeks, 3 gallons between the ages of 6 and 10 weeks, and 4 gallons between the ages of 10 and 20 weeks.

DISEASE AND MORTALITY ASCRIBED TO DIET

When disease of unknown origin appears among chickens, it is extremely important to have a poultry pathologist examine a few affected birds while they are still alive or soon after death. The first impulse of many poultrymen seems to be to take a sample of feed and try to have an analysis made. This course of action hardly ever results in a solution of the problem. Even if a case of poisoning is involved—and such cases are extremely rare—the feed analyst should have the pathologist's report before undertaking his investigation. The experience of many laboratories shows that nearly all of the samples of feed alleged to have killed chickens proved on investigation to be perfectly harmless.

When feeds are at fault, the fault is almost always deficiency rather than presence of a harmful ingredient. As stated previously

practical diets for chickens sometimes are deficient in vitamin A or D, or riboflavin or mangenese. Each of these deficiencies is much more easily detected by examining the chickens than by examining the feed. Deficiency of protein, calcium, phosphorus, or salt also may occur and may require analysis of the feed for conclusive demonstration, but here, too, there should first be an examination of the chickens.

MISCELLANEOUS EFFECTS OF DIET

Feather picking and cannibalism are related to diet and also to management. They are likely to occur in birds that are overcrowded and fed diets low in fiber or in salt. Very often feather picking and cannibalism can be stopped by increasing the salt content of the diet for 2 or 3 days. This may be done by adding 2 percent of salt to an all-mash diet or 4 percent to a mash that is being fed with grain, or simply by sprinkling salt over the mash in the hoppers. This treatment should not be continued for longer than 2 or 3 days, as continuous feeding of a diet high in salt is injurious. If feeding extra salt does not stop cannibalism, it may be necessary to remove the tip of the upper beak of each bird. This operation is painless if properly done. About three-sixteenths of an inch of the upper beak may be removed with a sharp knife or a hot soldering iron.

Egg eating may be the result of overcrowding, an insufficient number of nests, or deficiency of calcium or vitamin D. It is not readily corrected by changing the diet. If only a few hens in a flock have acquired this habit, as is often the case, it is probably best to dispose of the offenders.

Examination of chicks that die before reaching the age of 6 weeks often reveals erosion or ulceration of the gizzard lining. Most day-old chicks have at least a few small defects in the lining of the gizzard and the diet fed determines whether these disappear or increase in size and number. Disappearance of the lesions is favored by diets containing oats, wheat, or wheat millfeeds.

Questions are often asked regarding the possible relation of blood spots and meat spots in eggs to nutrition of the flock. It has been reported that fewer eggs with blood spots were produced by hens on grass range than by hens confined to a laying house, but experiments at Beltsville have not confirmed this report and have not demonstrated any relationship between feeding and the number of blood spots. Attempts to correct this condition by changes in the feeding program are, therefore, not recommended. The tendency to produce eggs with blood spots is known to be inherited.

EFFICIENCY OF UTILIZATION OF FEED

Utilization of Feed for Growth

Only a part of the feed eaten by young chickens can be used for growth. A bird does not digest all of its feed, and of that which is digested, part must be used to maintain the temperature of the body and to maintain all the processes necessary to the continuation of life whether growth occurs or not. As growing chickens become larger,

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the quantity of feed required for maintenance becomes larger and accounts for an increasing proportion of the total feed eaten. This means that a decreasing proportion of the total feed can be used for growth, which is the same as saying that the efficiency of feed utilization for growth decreases as chickens increase in weight.

The quantities of feed required to obtain certain selected average live weights of male and female chickens of two breeds are shown in table 2. The figures show that each half-pound addition to the live weight of the chicken requires more feed than the previous half-pound.

Utilization of Feed for Egg Production

A laying bird uses feed not only for egg production but also for maintenance and in some cases for increasing her weight. As an average, nearly 1⅓ ounces of water and 1½ ounces of feed, in addition to that required for maintenance and growth, are required for the production of an egg.

If two hens have the same weight, their maintenance requirement will be the same, and the one laying the greater number of eggs will require more total feed than the other, but will use her feed more efficiently since a greater proportion will go for egg production and a smaller proportion for maintenance. If two hens of different

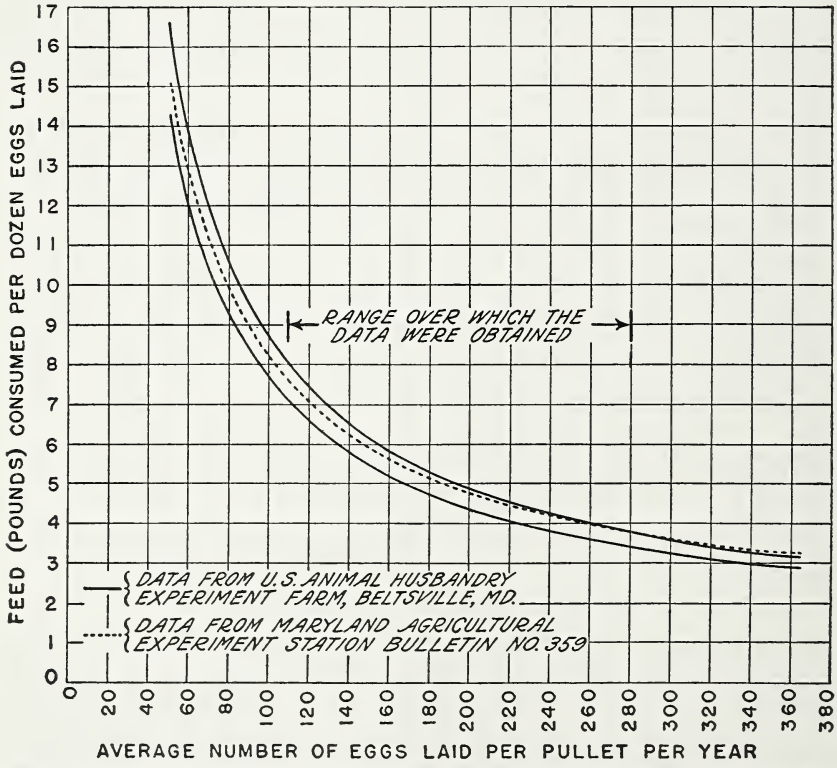

Figure 3.—Chart showing relation between rate of egg production and feed consumption per dozen eggs laid. (From Yearbook of Agriculture, 1939.)

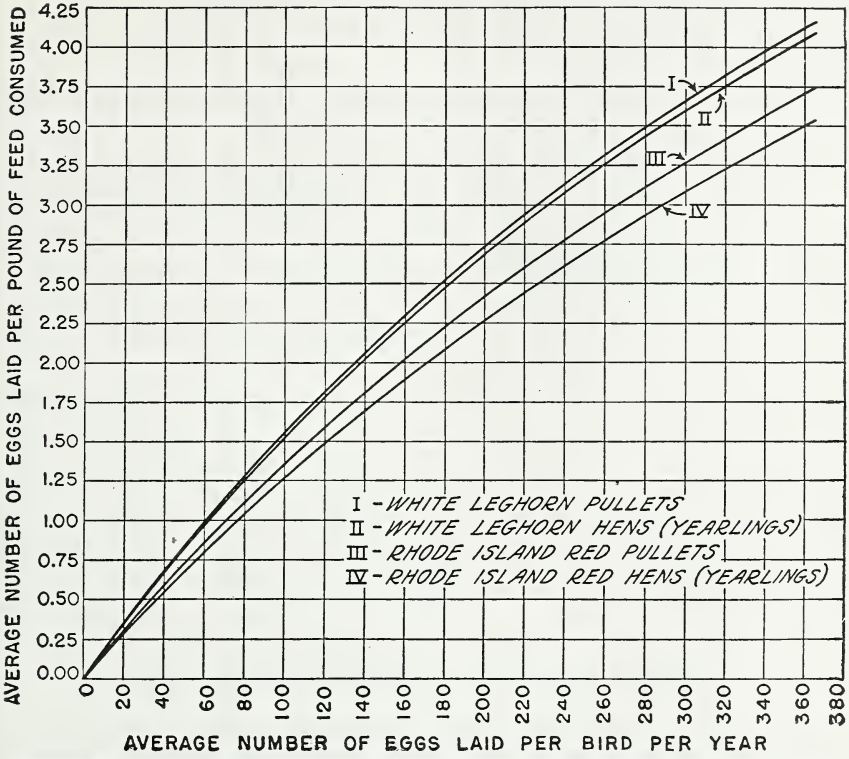

FIGURE 4.—Chart showing relation between rate of egg production and number of eggs laid per pound of feed consumed by pullets and hens of two breeds. (From Yearbook of Agriculture 1939.)

weights lay eggs at the same rate, the lighter of the two will require less feed and be more efficient than the heavier since a smaller proportion of her feed will be used for maintenance. These facts are illustrated in figures 3 and 4 which show the relationship between the number of eggs laid per pullet per year and the number of pounds of feed consumed per dozen eggs laid, and between the number of eggs laid per bird per year by two different breeds and the number of eggs laid per pound of feed consumed.

Utilization of Feed for Fattening or Finishing

The fattening of chickens, strictly speaking, is usually not an economical process. A finishing period before marketing sometimes is economical. The gains made by young chickens during the finishing process are really due to growth and not fattening, unless fattening is induced by administration of a synthetic hormone or drug having hormone-like action. Broilers which weigh 1½ to 2 pounds at the beginning of the finishing process require 3¼ to 4¼ pounds of feed for each pound of gain if they are of one of the heavy breeds. If they are of one of the light breeds, they may require 4½ to 5½ pounds of feed per pound of gain. Roasters that weight 4 to 5 pounds require 4½ to 7 pounds of feed per pound of gain and capons and fowls

require 8 to 12 pounds of feed per pound of gain during the finishing or fattening period.

TABLE 2.—*Feed required to obtain various average live weights with 2 common breeds of chickens*

Average live weight in pounds	Kind of chicken and quantity of feed required per bird			
	White Leghorns		Rhode Island Reds	
	Females	Males	Females	Males
	Pounds	*Pounds*	*Pounds*	*Pounds*
0.5	1.4	1.3	1.2	1.1
1.0	3.2	3.0	2.9	2.5
1.5	5.4	4.9	4.7	4.1
2.0	8.0	7.2	6.9	5.7
2.5	11.2	9.9	9.3	7.5
3.0	15.6	13.3	12.1	9.5
3.5	22.0	17.9	15.5	11.7
4.0	---	24.8	19.5	14.1
4.5	---	39.8	23.4	17.0
5.0	---	---	27.5	20.3

FEED FORMULAS AND FEEDSTUFFS

The importance of satisfactory formulas for poultry feeds is generally recognized. The quality of the ingredients used in preparing a feed is just as important as the formula, but this fact is not always appreciated. A formula feed with one ingredient of inferior quality is as undependable as a chain with one weak link. Since this is true, it is necessary to discuss formulas and ingredients together. Tables 3 to 11 present a wide variety of formulas for different purposes. Still other variations are possible.

GRAINS

Grains and grain products ordinarily make up more than half the diet of chickens. All the mash formulas in this Circular contain yellow corn, because it is easier to make a good mash with this grain than without it. Satisfactory mashes can be made in which the principal grain is wheat, barley, or grain sorghum instead of corn. In fact, almost any combination of grains can be used in a mash, but not all such combinations will be equally satisfactory. A mash containing corn is likely to be more palatable to chickens than one not containing it. If corn is omitted and the levels of wheat and barley are increased, care should be taken that these grains are not too finely ground, as grinding to a floury consistency reduces their palatability.

Yellow corn, unlike the other common grains, contains substances which the chicken converts into vitamin A. However, its content of such substances is small compared with the vitamin A potency of alfalfa leaf meal and vitamin A and D feeding oil, and has not been taken into account in formulating the mashes in this bulletin.

TABLE 3.—*All-mash chick-starting diets*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	25. 0	25. 0	25. 0	25. 0	25. 0
Pulverized oats or ground wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	17. 9	11. 9	19. 9	14. 9	20. 4	13. 4
Wheat middlings	-----	10. 0	-----	10. 0	-----	10. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Soybean meal	20. 0	16. 0	15. 0	11. 0	16. 0	14. 0
Cottonseed meal, peanut meal, corn-gluten meal, or soybean meal	10. 0	10. 0	10. 0	10. 0	10. 0	10. 0
Fish meal	4. 0	4. 0	-----	-----	2. 0	2. 0
Meat meal	-----	-----	8. 0	8. 0	4. 0	4. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	5. 0	5. 0	5. 0	4. 0	5. 0	4. 0
Steamed bonemeal, defluorinated superphosphate, or other low-fluorine calcium phosphate	1. 5	1. 5	. 5	. 5	1. 0	1. 0
Ground limestone or oystershell	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
Manganized salt	. 5	. 5	. 5	. 5	. 5	. 5
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram) [1]	. 1	. 1	. 1	. 1	. 1	. 1

[1] See footnotes 2 and 3 for table 1.

TABLE 4.—*All-mash chick-growing diets*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	25. 0	25. 0	25. 0	25. 0	25. 0
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	32. 9	21. 9	34. 9	23. 9	38. 4	28. 4
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Soybean meal	16. 0	12. 0	12. 0	8. 0	4. 0	4. 0
Cottonseed meal, peanut meal, corn-gluten meal, or soybean meal	5. 0	5. 0	5. 0	5. 0	5. 0	-----
Meat meal or fishmeal	-----	-----	3. 0	3. 0	9. 0	9. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	2. 0	2. 0	2. 0	2. 0	2. 0	2. 0
Steamed bonemeal, defluorinated superphosphate or other low-fluorine calcium phosphate	2. 5	2. 5	1. 5	1. 5	-----	-----
Ground limestone or oystershell	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
Manganized salt	. 5	. 5	. 5	. 5	. 5	. 5
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram) [1]	. 1	. 1	. 1	. 1	. 1	. 1

[1] See footnotes 2 and 3 for table 1.

TABLE 5.—*Chick-growing mashes to be fed with grain*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	23. 8	25. 0	25. 8	25. 0	28. 8
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	9. 3	-----	11. 8	-----	14. 8	-----
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Soybean meal	27. 0	23. 0	21. 0	17. 0	14.	10. 0
Cottonseed meal, peanut meal, corn-gluten meal, or soybean meal	10. 0	10. 0	10. 0	10. 0	10. 0	10. 0
Meat meal or fish meal	-----	-----	5. 0	5. 0	10. 0	10. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	6. 0	6. 0	6. 0	6. 0	6. 0	6. 0
Steamed bonemeal, defluorinated superphosphate, or other low-fluorine calcium phosphate	4. 5	4. 0	3. 0	3. 0	2. 0	2. 0
Ground limestone or oystershell	2. 0	2. 0	2. 0	2. 0	2. 0	2. 0
Manganized salt	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram) [1]	. 2	. 2	. 2	. 2	. 2	. 2

[1] See footnotes 2 and 3 for table 1.

TABLE 6.—*All-mash laying diets*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	25. 0	25. 0	25. 0	25. 0	25. 0
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	31. 2	20. 2	33. 7	22. 7	34. 1	22. 6
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	-----	-----
Soybean meal	15. 0	11. 0	12. 0	8. 0	13. 0	10. 0
Peanut meal, corn-gluten meal, or soybean meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Meat meal or fish meal	-----	-----	2. 0	2. 0	2. 0	2. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	2. 0	2. 0	1. 0	1. 0	4. 0	4. 0
Steamed bonemeal, defluorinated superphosphate or other low-fluorine calcium phosphate	3. 0	2. 0	2. 5	1. 5	2. 5	1. 5
Ground limestone or oystershell	3. 0	4. 0	3. 0	4. 0	3. 5	4. 0
Manganized salt	. 5	. 5	. 5	. 5	. 5	. 5
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram) [1]	. 3	. 3	. 3	. 3	. 4	. 4

[1] See footnotes 2 and 3 for table 1.

TABLE 7.—*Laying mashes with which an equal weight of grain is to be fed*[1]

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	20. 5	25. 0	23. 5	25. 0	23. 7
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	5. 0	-----	9. 0	-----	9. 7	-----
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	-----	-----
Soybean meal	30. 0	26. 0	24. 0	20. 0	25. 0	22. 0
Peanut meal, corn-gluten meal, or soybean meal	10. 0	10. 0	10. 0	10. 0	10. 0	10. 0
Meat meal or fish meal	-----	-----	4. 0	4. 0	4. 0	4. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	5. 0	4. 0	4. 0	4. 0	7. 0	6. 0
Steamed bonemeal, defluorinated superphosphate, or other low-fluorine calcium phosphate	6. 0	5. 0	5. 0	4. 0	5. 0	4. 0
Ground limestone or oystershell	2. 5	3. 0	2. 5	3. 0	2. 5	3. 5
Manganized salt	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram)[2]	. 5	. 5	. 5	. 5	. 8	. 8

[1] When these mashes are fed, limestone or oystershell should be supplied in hoppers. [2] See footnotes 2 and 3 for table 1.

TABLE 8.—*All-mash breeding diets*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	25. 0	25. 0	25. 0	25. 0	25. 0	25. 0
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	30. 7	19. 7	32. 7	23. 7	31. 2	22. 7
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Soybean meal	9. 0	5. 0	5. 0	4. 0	7. 0	7. 0
Peanut meal, corn-gluten meal, or soybean meal	5. 0	5. 0	4. 0	-----	5. 0	-----
Fish meal	4. 0	4. 0	4. 0	4. 0	2. 0	2. 0
Meat meal	-----	-----	4. 0	4. 0	4. 0	4. 0
Riboflavin supplement (20 micrograms riboflavin per gram)	5. 0	5. 0	5. 0	4. 0	5. 0	4. 0
Steamed bonemeal, defluorinated superphosphate, or other low-fluorine calcium phosphate	2. 5	2. 0	2. 0	1. 0	2. 0	1. 0
Ground limestone or oystershell	3. 0	3. 5	2. 5	3. 5	3. 0	3. 5
Manganized salt	. 5	. 5	. 5	. 5	. 5	. 5
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram.) [1]	. 3	. 3	. 3	. 3	. 3	. 3

[1] See footnotes 2 and 3 for table 1.

TABLE 9.—*Breeding mashes with which an equal weight of grain is to be fed* [1]

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	28. 5	18. 5	25. 0	22. 5	25. 0	21. 0
Ground oats or wheat	10. 0	-----	10. 0	-----	10. 0	-----
Ground corn, wheat, barley, or grain sorghum	-----	-----	8. 5	-----	5. 5	-----
Wheat middlings	-----	15. 0	-----	15. 0	-----	15. 0
Wheat bran	-----	10. 0	-----	10. 0	-----	10. 0
Alfalfa leaf meal	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0
Soybean meal	18. 0	14. 0	10. 0	10. 0	14. 0	10. 0
Peanut meal, corn-gluten meal, or soybean meal	10. 0	10. 0	8. 0	4. 0	10. 0	10. 0
Fish meal	8. 0	8. 0	8. 0	8. 0	4. 0	4. 0
Meat meal	-----	-----	8. 0	8. 0	8. 0	8. 0
Riboflavin supplement (20 micrograms riboflavin per gram) [2]	12. 0	11. 0	11. 0	11. 0	11. 0	10. 0
Steamed bonemeal, defluorinated superphosphate, or other low-fluorine calcium phosphate	5. 0	4. 0	3. 5	2. 5	4. 0	3. 0
Ground limestone or oystershell	2. 0	2. 0	1. 5	2. 5	2. 0	2. 5
Manganized salt	1. 0	1. 0	1. 0	1. 0	1. 0	1. 0
Vitamin A and D feeding oil (400 A. O. A. C. units vitamin D, 2,000 International Units vitamin A per gram) [3]	. 5	. 5	. 5	. 5	. 5	. 5

[1] When these mashes are fed, limestone or oystershell should be supplied in hoppers.

[2] A material containing 20 micrograms of riboflavin per gram has been included to make these formulas comparable with the others in this circular. Actually, in these formulas it would be desirable to have lower levels of materials containing greater concentrations of riboflavin. (See text, p. 20.)

[3] See footnotes 2 and 3 of table 1.

TABLE 10.—*Grain mixtures*

Ingredient	Diet No.—					
	1	2	3	4	5	6
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*	*Per-cent*
Yellow corn [1]	50	33. 4	33. 3	25. 0	50. 0	-----
Wheat	50	33. 3	33. 3	25. 0	-----	50. 0
Oats	-----	33. 3	-----	25. 0	25. 0	25. 0
Barley	-----	-----	33. 3	25. 0	25. 0	25. 0

[1] Cracked corn for chickens less than 12 weeks old; whole corn for older birds.

TABLE 11.—*Finishing diets* [1]

Ingredient	For broilers	For roasters, capons, and fowls
	Percent	*Percent*
Ground corn	40. 0	45. 0
Finely ground oats, wheat, or barley	30. 0	34. 0
Alfalfa leaf meal	3. 0	----------
Meat meal	5. 0	3. 0
Soybean meal or corn-gluten meal	14. 0	10. 0
Dried milk byproduct	6. 0	6. 0
Ground limestone	1. 5	1. 5
Salt	. 5	. 5

[1] It would be advantageous to add 3 to 5 percent of corn oil or soybean oil to these mashes when available and not too expensive. Enough water should be mixed with these mashes to allow the mixture to pour readily.

The maximum quantity of oats suggested in the tables is 10 percent, and this grain has been omitted from mashes containing wheat bran. Larger quantities of oats can be used, but oats, bran, and alfalfa leaf meal are all high in fiber. Chickens can utilize diets of higher fiber content than those recommended here, but high fiber reduces the efficiency of feed utilization. Oats for young chicks should be pulverized. This may be done for older birds also but is not essential.

Ground grain deteriorates in storage more rapidly than whole grain. Therefore, the grain should be ground as it is needed for the preparation of mashes, and the period of storage of mash feeds should be as short as practicable.

Wheat millfeeds may be included or omitted in the formulation of poultry feeds depending on their availability and price compared with the availability and price of grains. The wheat millfeeds contain 15 to 17 percent of protein compared with 8 to 12 percent found in most grains, and the protein content of course contributes to their value. The quantity of millfeed to be included in a formula should be limited by its fiber content. The fiber content of a few typical millfeeds and grains, in percent, is as follows: Wheat bran 9.5, wheat standard middlings 6.8, wheat flour middlings 4.4, wheat 2.4, corn 2.2, barley 5.7, and oats 10.6.

GREEN FEEDS

Most poultry mashes contain alfalfa meal or alfalfa leaf meal which may be either sun-dried or dehydrated. Other types of dehydrated green feed are sometimes used. The most important contribution of these materials is their vitamin A potency, which unfortunately is highly variable. To be of value in poultry feeds any dehydrated green feed should contain at least 100 and preferably 200 International Units of vitamin A potency per gram (45,000–90,000 units per pound). Alfalfa meals contain less protein and more fiber and, generally speaking, less vitamin A potency than do alfalfa leaf meals.

It has been demonstrated that in the case of growing chickens about 10 percent of the mash and grain feed can be saved by providing good pasture, which means young growing grass or legumes. Even more important is the economy that can be achieved by using a simplified mash formula for growing birds on pasture. For example, all of the alfalfa leaf meal, riboflavin supplement, and vitamin A and D feeding oil in the formulas in tables 4 and 5 could be replaced with grain if good pasture were available. The pasture itself would furnish all the nutrients provided by these ingredients with the exception of vitamin D, which would be provided by sunlight.

Green feed supplies much of the yellow coloring matter that is deposited in egg yolk and in the shanks and skin of chickens of some breeds. Yellow corn and corn-gluten meal also contribute. Yellow color is usually desired in the shanks and skin of market chickens, but in some markets there is a demand for eggs with pale yolks, making it necessary to omit or reduce the quantity of green feed from the diet of laying hens. The feeding of large quantities of meat meal, fish meal, or certain fish oils tends to reduce the intensity of the yellow color in shanks and egg yolks.

Protein Supplements

The formulas in tables 3 to 9 contain more protein supplement from vegetable than from animal sources. Such combinations have been chosen partly for the sake of economy but chiefly because experiments have indicated that they give better results. In fact, soybean meal can be depended on as the only protein supplement in diets for growing chickens or in diets for laying hens if the eggs are not to be hatched. In diets for starting chicks or for breeding birds, it is highly desirable to have at least a small amount of fish meal or if that is impracticable a somewhat larger amount of meat meal. The need for these animal protein supplements is not based on their protein content but on their content of an unknown vitaminlike factor. The importance of this factor in the diet of breeders is illustrated in figure 5.

In each of the formulas, the vegetable protein may consist entirely of soybean meal or it may be a combination of soybean meal and another plant-protein supplement. Cottonseed meal is not recommended as a component of diets for laying hens. When the eggs of hens fed cottonsteed meal are stored, they develop an olive color in the yolks and a pink tint in the albumen.

Soybeans are processed commercially by either the extraction or the expeller method. The soybean meal produced by either method is satisfactory for feeding provided it has been properly heated in processing. Although considerable variability exists among commercial meals, the chance of obtaining one that would fail to give satisfactory results in any of these formulas is very small. Raw soybeans are sometimes used in poultry feeds but they should not constitute more than 5 percent of the diet. They may be heated to increase their feeding value in the same way that commercial soybean meal is heated if circumstances justify the additional cost.

Meat meals, which contain about 55 percent protein, may be replaced in these formulas by meat-and-bone meals which contain about 50

percent protein, if the latter product is more readily available. Fish meals vary in protein content from about 55 to 65 percent and are of three principal types: Sardine (or pilchard), menhaden, and whitefish. Their variations in quality are related more to the method of processing than to source material.

The question is often asked as to whether fishy flavor might develop in the flesh of chickens or in eggs from the feeding of fish meal and fish oil. This would not occur as a result of feeding the quantities of

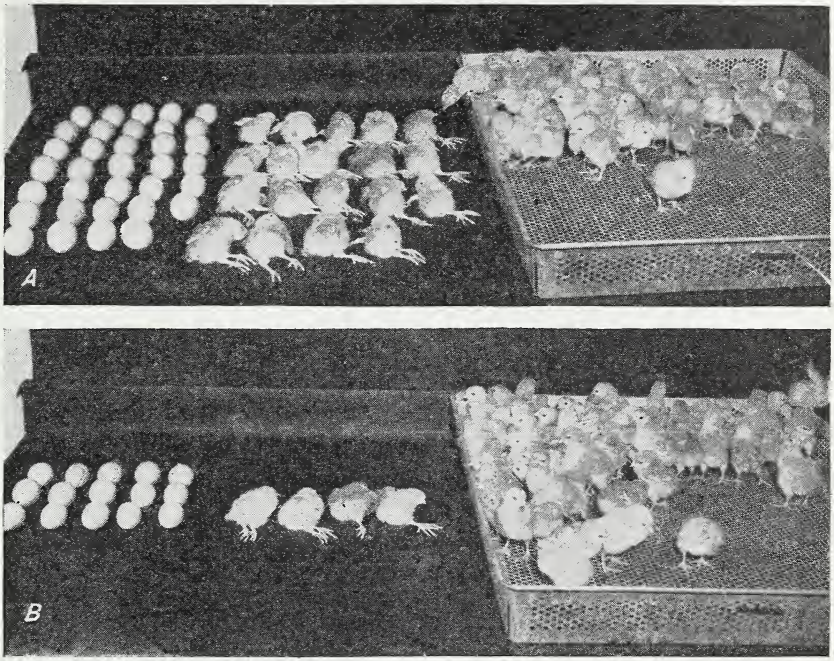

FIGURE 5.—Effects of properly and inadequately supplemented vegetable proteins. *A*, Of 100 eggs produced by hens receiving inadequately supplemented vegetable protein at a high level, 34 failed to hatch and 19 yielded chicks that died during the first week. *B*, Of 100 eggs laid by hens fed a similar diet supplemented with fish meal, 15 failed to hatch and 4 yielded chicks that died during the first week.

these materials recommended in this circular. If considerably larger quantities of both fish meal and fish oil are fed, fishy flavor is produced in the flesh of chickens.

VITAMIN SUPPLEMENTS

A great many riboflavin supplements are available and they range in potency from about 20 micrograms per gram, the figure used in calculating the formulas, to 850,000 micrograms per gram, the figure for synthetic riboflavin of 85-percent purity. The formulas were based upon a supplement containing 20 micrograms per gram because this is the approximate potency of several of the natural sources including dried milk byproducts and some fermentation byproducts.

Numerous commercial preparations having guaranteed potencies higher than this are sold under trade names. They may be used in these formulas at levels which supply the same quantity of riboflavin as the recommended level of the supplement containing 20 micrograms per gram.

With the exception of synthetic riboflavin, practically all the supplements contain other water-soluble vitamins. These are desirable since they help to insure adequate levels of these vitamins. However, with the possible exception of the breeder mashes, the mashes formulated in this circular contain enough of these vitamins from other sources so that the synthetic material could be used as the only riboflavin supplement. In the breeder mashes half the total potency of the riboflavin supplement could be furnished by the synthetic compound. As indicated in the footnote to table 9, it would be desirable to include a supplement of higher potency in the breeder mashes to be fed with grain rather than to depend entirely on high levels of supplements of relatively low potency.

Many riboflavin supplements, including milk byproducts, distillers' solubles, and other fermentation byproducts are laxative if fed at too high a level and for this reason, it is sometimes desirable to supply at least a part of the riboflavin in the form of a supplement of high potency. Combinations of high levels of riboflavin supplements with high levels of other laxative feedstuffs such as bran and minerals are especially undesirable.

When available, liquid skim milk or buttermilk may be given to chickens to drink and the level of riboflavin supplement in the mash may be reduced. A gallon of liquid milk is equivalent to 0.8 pound of the riboflavin supplement in the formulas.

Vitamin A and D feeding oils of various potencies are available, but the potency suggested in the formulas is the most common. Commercial preparations supplying vitamin D but no vitamin A are also available and could be used in these formulas provided the alfalfa leaf meal were of sufficiently high vitamin A potency. In the chick-starting and all-mash growing diets alfalfa leaf meal containing 100 International Units of vitamin A per gram would be sufficient for this purpose. In the growing mashes to be fed with grain, 200 units per gram would be required; in the all-mash laying and breeding diets, 150 units; and in the laying and breeding mashes to be fed with grain, 300 units. Obviously, this does not apply to the laying mashes which contain no alfalfa leaf meal; in them the vitamin A of the feeding oil is essential.

The phosphorus of grains and seeds is partially unavailable for chickens, as already stated. Its availability is increased by feeding high levels of vitamin D; it is increased more by feeding the vitamin D of activated animal sterol than by feeding the vitamin D of cod liver oil. The activated sterol is not generally superior to vitamin A and D oils in this respect since these oils contain activated sterol as a major source of vitamin D potency.

Mineral Supplements and Grit

Among sources of calcium and phosphorus, several choices are indicated in the tables. The suggested levels of steamed bonemeal

or substitute are based on an assumed phosphorus content of 15 percent as in steamed bonemeal. Materials containing more or less phosphorous should be used at proportionately lower or higher levels. In the process of defluorination of superphosphate, proper regulation of the heating process is essential to the production of material high in available phosphorus.

The danger of obtaining defluorinated superphosphate low in available phosphorus is probably small, but if a question arises a quick test can be made on the basis of the rough parallelism between availability and solubility in 0.25 percent hydrochloric acid. It is highly desirable that the fluorine content of defluorinated phosphates be 0.1 percent or less, but it may be possible under some conditions to justify the use of phosphates containing 0.1 to 1.0 percent of fluorine.

Limestone to be used in poultry feed should contain at least 90 percent, and preferably 95 percent or more, of calcium carbonate.

In meeting the calcium requirements of laying hens the common practice is to depend in part on pulverized limestone or oyster shell in the mash and in part on crushed limestone or oystershell fed in separate hoppers, a practice which has its advantages. Although the crushed limestone or oystershell undoubtedly performs some of the functions of grit, it is advisable to provide insoluble grit to confined birds. Both insoluble grit and limestone grit are prepared from crushed stone which is customarily screened to the following sizes: Chick size which passes No. 12 mesh but is held by No. 20; medium size passes No. 8 mesh but is held by No. 12; large size passes No. 5 mesh but is held by No. 8; and turkey size passes No. 4 mesh but is held by No. 5.

The manganized salt to be used in the formulas in this circular may be prepared by mixing 100 pounds of dairy or table salt with 3 pounds of finely pulverized technical anhydrous manganous sulfate. No lumps should be present in either material at time of mixing.

FEEDING PRACTICES

Under modern practices more and more poultrymen have come to rely on the products of commercial feed manufacturers rather than on home-mixed feeds. The commercial manufacturer has several important advantages among which are better control of the quality of ingredients, better mixing facilities for handling small quantities of high-potency vitamin supplements, and usually wider choice of ingredients. Probably the principal reason for continued feeding of home-mixed feeds is the opportunity it affords to utilize home-grown materials.

The individual poultryman who mixes his feed must be very sure to do the job thoroughly. Ingredients used in greatest quantity should be weighed first and other ingredients added to them. Any ingredients used in very small quantity should be mixed with a little ground grain before being added to the mash. If this is done with both vitamin and mineral supplements, separate mixtures should be made. If vitamin and mineral supplements together are premixed with the same sample of grain, the destruction of the vitamins is likely to be hastened. Liquids should be thoroughly mixed with a small portion of grain before being added to the mash. Mixing vitamin A and D oil with

finely ground oats helps to prevent the destruction of the vitamin A in the final feed mixture.

Mashes for all types of poultry are sometimes made into pellets to prevent waste, eliminate dust, and increase feed consumption. These objectives can be achieved by the use of pellets; whether they are most economically achieved by this means remains to be seen. When feed consumption is abnormally low, as in severe cold weather or in case of disease, the use of pelleted mash may help birds to resume their normal habits.

A commercial-formula feed should be made for a specific purpose. The manufacturer should state on the tag or bag the purpose for which the feed was made and the directions for feeding it. The purchaser should follow the manufacturer's directions specifically. For the most part the following directions are generally applicable to the feeding of chickens, but they are intended especially for those who use the mashes indicated in this publication.

Feeding Baby Chicks

Starting mash and drinking water should be provided for baby chicks as soon as they are placed around the brooders and should be available to them at all times. To encourage them to begin eating, feed should be supplied not only in feeders but also on pieces of cardboard such as clean egg-case flats. These may be removed after the second day. The starting mash should be fed as an all-mash diet until the chickens are at least 4 weeks old, except that fine grit may be mixed with the mash or supplied in separate hoppers.

As an alternative to the procedure recommended above, chicks may be given finely cracked corn instead of mash during the first 2 or 3 days after hatching. This practice helps to prevent the condition known as "pasting up", in which a mass of fecal material collects around the vent. It should be remembered that "pasting-up" is usually evidence of irregularities in brooding temperature. Even if cracked corn is not fed, this condition should not occur if care is taken to maintain the proper temperature (95° F.) under the brooder during the first week with a drop in temperature of about 5° each week thereafter until a heated brooder is no longer needed. If cracked corn is fed to newly-hatched chicks it should not be fed longer than 3 days.

There is evidence that chickens grow more rapidly during the first 10 days or 2 weeks of life when fed a diet containing 30 to 32 percent of protein than when fed the usual starting mash containing 21 percent of protein. Special high protein starting mashes to be fed only during the first 10 to 14 days have therefore been suggested. Thus far such mashes have not been tested extensively under practical conditions.

It is important to have enough feeding and drinking space. At first 2 inches of feeding space and ½-inch of drinking space per chick should be provided. As the chicks grow, the feeding and drinking space must be increased.

Feeding Broilers

The starting mashes in table 3 are also good broiler mashes. For broilers it would be desirable that the mashes contain some corn-gluten meal, as this ingredient would increase the quantity of yellow

pigment in the shanks and skin. These mashes could be fed as all-mash diets until the birds are marketed, but the common practice is to feed some whole grain during the last few weeks before marketing. Grain should not be fed until the birds are at least 8 weeks old. Rapid growth is more important and, therefore, early grain feeding is more objectionable in broilers than in pullets for flock replacement.

Feeding Layers and Breeding Stock

The all-mash laying and breeding diets in tables 6 and 8 are intended to be complete diets in all respects. Additional limestone or oystershell should not be supplied since there is enough calcium in the mashes. Insoluble grit may be supplied in separate hoppers and would, in fact, be desirable for confined chickens that could not pick up stones and pebbles from the range.

The laying and breeding mashes in tables 7 and 9 are designed to be fed with grain in about equal parts. The grain may be whole yellow corn or any one of the mixtures in table 10. As indicated in the footnotes to tables 7 and 9, extra limestone or oystershell should be supplied in hoppers when these mashes are fed.

When grain and mash are fed, the two are sometimes supplied in separate hoppers, permitting free choice. Often this procedure results in consumption of too much grain. To prevent this, grain is usually fed once or twice a day, the amount being regulated so that grain consumption will approximately equal the consumption of mash, which is available to the birds at all times. Grain should be placed in separate hoppers or in the mash hoppers (fig. 7). It is often scattered in the litter, but this practice is likely to be wasteful.

Feeding Pullets for Flock Replacement

When pullets are 6 to 8 weeks old, a change is usually made in their diet. Any one of three things may be done. First, they may be changed from the all-mash starter to an all-mash growing diet, and continued on it until they are almost ready to lay. Second, they may be fed a growing mash, like one of those in table 5, plus a grain mixture. Third, they may be continued on the starting mash, but with grain fed in addition.

Grain feeding is sometimes begun when chickens are 4 weeks old, but is not recommended for chickens younger than 6 to 8 weeks. Whenever it is begun, the quantity of grain should be small at first and should be increased gradually until, at about 15 weeks of age, the birds are eating equal parts of mash and grain. Since grain is ordinarily cheaper than mash, its use is more economical. Grain also contains less protein and less of certain vitamins than does the mash. Its use is justified on nutritional grounds because the chicken's requirement for these vitamins in units per pound of feed decreases as the bird grows; and because, as the bird grows, it becomes less sensitive to decreased concentration and quality of protein.

The common practice is to rear pullets on range, the value of which has been described. During the hot summer months it is advisable to place the feed and water where there is shade (fig. 6) so that the birds may eat enough for satisfactory growth.

Limiting the quantity of mash and grain supplied to pullets on range will make them eat more grass, but such a practice is likely also to decrease the rate of growth. It is recommended, therefore, that feed be available in the hoppers at all times.

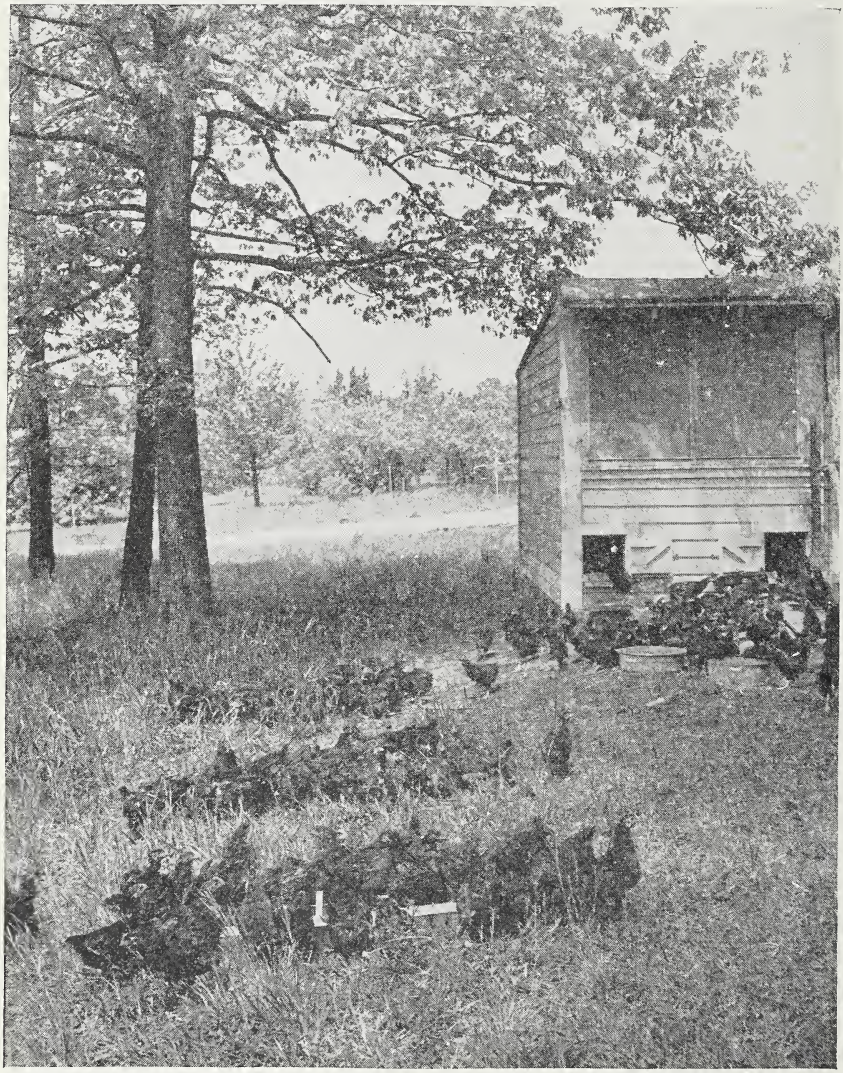

FIGURE 6.—Sunshine provides vitamin D, but in hot weather, feeders should be placed in the shade to encourage feed consumption.

About 1 month before pullets are expected to begin laying, the growing mash should be gradually replaced by laying mash. Various mixtures of the two mashes may be fed during a period of 2 weeks while the change is being made. If growing mash and laying mash are similar in composition, as are some of those in tables 5 and 7, the change may be made abruptly, but a gradual change is safer.

Fattening, or Finishing, Chickens

Finishing chickens for market is done most economically on a large scale at specially equipped feeding stations and probably should not be attempted by the individual poultryman under ordinary conditions. In certain cases, it may be profitable for the poultryman to undertake this operation if he has chickens for market that are healthy but in poor flesh for any reason. Finishing diets are usually fed as wet mashes, two or three times a day, to birds that are confined in fattening batteries or in small pens. It is important not to overfeed on the first day. Beginning on the second day, the chickens should be given at each feeding as much as they will eat in half an hour.

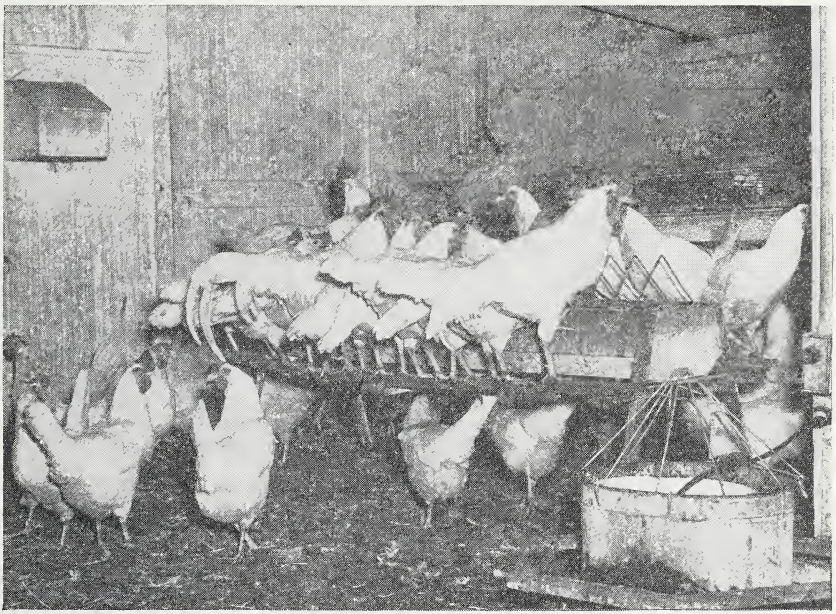

Figure 7.—A feeder designed to prevent waste and contamination of the feed. It is important to provide enough feeding space.

Broilers may be fed a finishing diet for 1 to 2 weeks, but the finishing period for older birds is usually not longer than 1 week.

If liquid skim milk, buttermilk, or whey is available, a good finishing mash may be made from equal parts of ground corn and finely ground oats plus 1.5 percent of ground limestone, with enough milk or whey added to make a mixture that will pour readily. If liquid milk or whey is not available, 9 parts of water and 1 part of dried milk byproduct may be used. The value of milk products in finishing mashes is probably in their favorable effect on palatability rather than in the nutrients they contain.

The simple combinations of feeds described above are suitable for the finishing of chickens on a small scale. If the operation is to be undertaken on a larger scale, and especially if it involves the feeding of broilers, it is better to rely on a formula like one of those in table 11.

If yellow pigmentation of shanks and skin is desired, as it commonly is in broilers, it would be well to use yellow corn and corn-gluten meal in the mash. If yellow color is not desired, as is sometimes the case with older birds, white corn and soybean meal should be used.

It has been amply demonstrated that deposition of fat can be increased and carcass quality improved both in broilers and in older male birds by implanting pellets of diethyl stilbestrol under the skin. This synthetic compound is a potent drug which produces physiological effects similar to those of the female sex hormone. When preparations containing it are used, the directions of the manufacturer should be followed with great care, as excessive doses produce unfavorable effects on feed consumption and body weight.

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