MINNESOTA FEEDS SERVICE

UNIVERSITY OF MINNESOTA AGRICULTURE JUN 7 1956 LIBRARY INSTITUTE OF AGRICULTURE

University of Minnesota Agricultural Extension Service, St. Paul May 31, 1956

Fat and Protein in Poultry Rations

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Feeds for chickens and turkeys are continually becoming more efficient. This is amply proved by the great reduction in pounds of feed now required to produce a pound of poultry meat or one dozen eggs. Today's feeds are often called by such terms as "high efficiency," "high energy," "high protein and high energy," and even "ultra-high efficiency." Let's look back a bit. What have been the actual changes in poultry rations to bring about today's more efficient feed conversion and new terminology?

Energy Replaces Fiber

The steps have been many. However, the most significant changes during the past few years have involved dietary adjustments in fiber and in calorie and protein levels.

Almost everyone can remember the relatively large amounts of wheat byproducts, such as bran and middlings, and other high-fiber feeds, including alfalfa and oats, routinely used in formulas only a few years ago. Eliminating or limiting the use of these so-called "low energy" ingredients noticeably improved efficiency of the feed. The change was marked by a period of high-energy ration formulation, beginning about 1950.

High-Energy Application

A few years ago, high-energy rations were used primarily as starting and broiler-type rations. This limited application was due to a lack of research with older chickens and turkeys. Also, there was a general reluctance to make rather drastic changes, because unusual nutrient deficiencies or imbalances might result. Use of these high-efficiency formulations spread rapidly, however, and additional research soon demonstrated their suitability for laying and breeding hens to lower production costs.

Part of the work with high-energy diets included the use of animal and vegetable fats as supplements. Most of the early work demonstrated improved feed efficiency, but did not show any particular change in growth or production rate. With many types of rations, it appeared that a simple shifting of ingredients—so that the energy portion of the ration would be provided mainly by yellow corn—was sufficient to raise the energy (calorie) level and achieve improved feed efficiency. It was natural that the research would take this direction, because of the higher cost of providing calories in the form of animal or vegetable fats than as yellow corn.

During this period, it was commonly felt that a broiler-type ration was very efficient if it contained about 900 productive-energy calories per pound of ration. Higher levels (with the calories usually supplied in the form of fat additions) did not seem to offer any marked improvement. Thus additional study to determine nutrient-calorie relationships was started in several different laboratories.

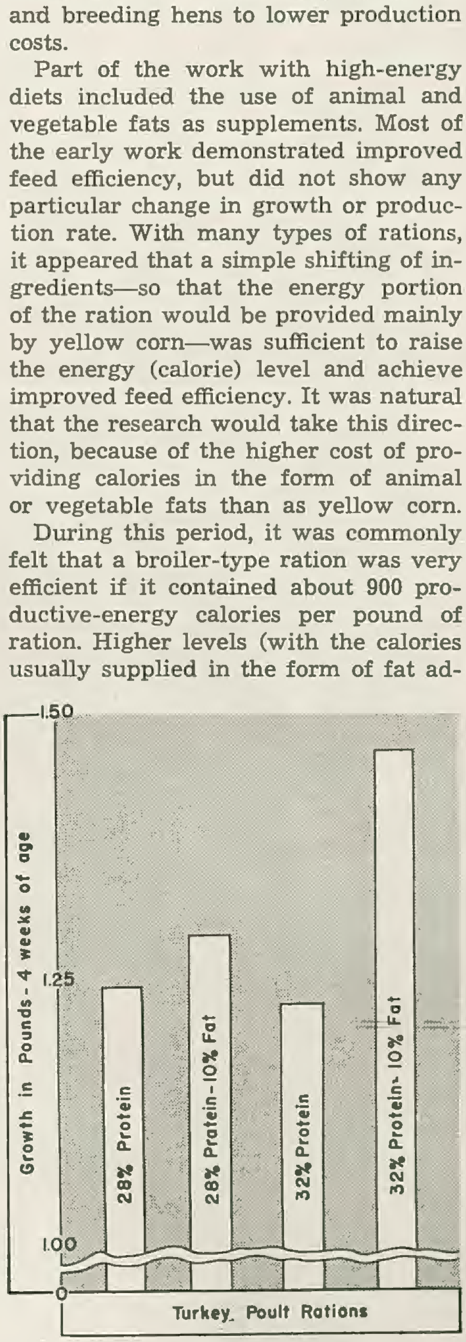

Fig. 1. How added dietary protein and energy (fat) increased turkey poult growth.

Protein-Energy Relationships

The total protein requirement of the chick or hen has always been a somewhat debatable topic. Apparently there are conditions affecting nutritional responses at different protein levels. Logically, protein was one of the early nutrients studied in relation to the calorie content of the diet. Fortunately, this type of research has been extremely productive in indicating new levels of ration performance.

Some of the earliest work on this protein-energy relationship was conducted at the University of Maryland. That resulted in a proposed "yardstick," called the **calorie-protein ratio**, for evaluating ration efficiency. This yardstick has been used frequently during the past year. It has proved to give a rather good indication of the optimum relationship between calorie and protein levels; however, there are exceptions to the theory. Therefore, in this report, a minimum of emphasis is placed on it.

Practical Energy Measures

Two differing sets of feed-energy values are available for our use. These are the productive energy ("PE") and metabolizable energy ("ME") values.

The **productive energy values** were developed by G. S. Fraps of the Texas Agricultural Experiment Station. They are summarized in Texas Bulletin 678 (1946).

More recently, the **metabolizable energy values** were published by F. W. Hill and D. L. Anderson of Cornell University, and by H. W. Titus in his book "Scientific Feeding of Chickens" (Interstate Press, 1955). Since feed energy is converted to heat, both sets of values use the term "calorie" as a quantitative measure of feed energy.

(Continued on page 2)

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Published by the University of Minnesota Agricultural Extension Service, Institute of Agriculture, St. Paul 1, Minnesota.

Feed Service Committee—Cora Cooke, chairman; Rodney Briggs; William Flemming; Lester Hanson; Harold Jones; Hal Routhe; Harold Searles; and Harold B. Swanson. Earl Brigham, editorial assistant for the committee.

(Continued from page 1)

As is obvious from table 1, it is necessary to be specific when referring to the calorie content of any mixture of feed ingredients. Calorie levels of a feed would be considerably lower when calculated according to productive energy values than when expressed in terms of metabolizable energy.

Kinds of Energy

Scientific reports, as well as commercial brochures, have included several different types of "calories" in evaluating individual ingredients and complete rations. We can be more precise in defining and determining diet energy. Correctly, the term "calorie" as used in animal nutrition studies is the so-called "large" (or capitalized) Calorie.[1] This calorie is based on the unit of heat which can raise the temperature of one kilogram of water by 1° Centigrade. Obviously the kind of energy is also important. Coal, for example, is a source of tremendous energy; but the energy could not be made readily available for animal feeding.

The total or **gross energy** of a feed is not a satisfactory measure. The presence of substances such as lignin, cellulose, and pentosans prevent complete digestion.

Total digestible nutrients or **digestible energy** would be a good measure—except that the method of determination (subtracting fecal energy from feed energy) is complicated by the presence of urine in the bird's droppings.

Metabolizable energy (ME), as mentioned above, is a measure recently introduced for general use. It is that portion of feed energy which is actually liberated in the animal body and used for the production of carcass, product (eggs), work, and heat. It is measured by subtracting the calories in the feces and urine from the calories in the feed; then correcting for the portion of retained protein energy (in the growing animal) which cannot be metabolized.

Productive energy (PE) or **net energy** (the values developed by Fraps of Texas) is a measure to which most poultrymen and nutritionists have already become accustomed. It includes the feed energy retained as carcass and product (eggs), plus only that energy required for maintenance of body processes and activities. Since different feeds lose varying percentages of their ME as heat loss, PE (which does not include this heat loss) is a more exacting estimate of utilizable energy.

Calories in Practical Rations

The poultry feeds which we recommend today contain appreciably higher levels of calories, by virtue of improved formulation.[2] The calorie levels per pound are 896 (PE) and 1,309 (ME) for our chick starter diets, and 964 (PE) and 1,431 (ME) for our broiler diets. Our present layer and breeder rations also contain over 950 PE calories or 1,350 ME calories per pound.

These rations are very efficient in converting feed to meat or eggs, and also have minimum ingredient costs. Furthermore, not more than 100 pounds of oats nor more than 50 pounds of alfalfa meal are used per ton of any of the various rations listed.

Energy Limitation

These rations have not included the addition of large amounts of animal or vegetable fats to create additional increases in the energy content. Recent experimental work at the University of Minnesota, and elsewhere, has indicated that improved results can be obtained with the addition of 5 to 15 per cent fat to certain rations. Evidence also seems to indicate that the total protein level should be increased at the same time, for maximum utilization of the feed energy.

Results in our laboratories have indicated that marked increases in growth of young chicks and turkey poults occur when both protein and fat levels are increased above those usually recommended. Broad Breasted White turkey poults have made remarkable growth increases when protein content of the ration was increased from 28 to 32 per cent, and a 10 per cent addition of fat was made. (See figure 1.) Both the 28 per cent protein ration, and the 32 per cent ration with 10 per cent fat, however, contained calorie-protein ratios of 29 (total PE calories divided by percentage of protein). This shows the inadequacy of the calorie-protein ratio for predicting performance in such cases. Similar ration changes have caused comparable improved performance of chicks.

Other Nutrient Problems

The exact limitations on how much protein and energy can be concentrated in the ration are not known. We do have evidence, however, to indicate that other factors may become limiting at the higher energy and protein levels. Specific work with turkey poults in our laboratories has indicated the need for amino acid supplementation with the higher levels of protein and fat.

The practical aspects of these extremely high levels of protein and fats have not been fully realized. Considerably more experimental work will be necessary before such rations can be routinely incorporated into recommended formulas.

Future Application

We are confident that additional research will develop rations of improved efficiency for layer and breeder hens, in addition to those now developed chiefly for meat production. Addition of animal and vegetable fats to some poultry feeds is already a standard practice. As our knowledge regarding optimum balance of all nutrients increases, we should be able to achieve an even sounder, and economical, inclusion of high dietary energy and protein levels.

[1] The term is so used in this article. The Calorie (capitalized) technically represents a value 1,000 times greater than a "calorie" (not capitalized). But it has become so common in popular writing to use a non-capitalized style for the larger value that the practice is followed here.

[2] For recommendations, see "Formula Chart for Chicken Mashes," University of Minnesota Poultry Department Publication 5601.

Table 1. Energy values for some common feed ingredients

Ingredient	Calories per pound	
	PE*	ME†
Alfalfa meal (17%-18% protein)	308	348
Animal fat	2,760	3,960
Vegetable oil	2,760	3,894
Corn, ground	1,145	1,535
Fish meal (62% protein, 5.6% fat)	898	1,230
Meat and bone scrap (50% protein, 10% fat)	724	1,152
Oats (good quality)	760	1,133
Soybean oil meal (44% protein, 1% fat)	565	1,103
Wheat, whole	1,024	1,381
Wheat standard middlings	513	1,043
Wheat bran	478	759
Whey, dried	490	1,242

* "Productive energy" values (G. S. Fraps). † "Metabolizable energy" values (H. W. Titus).

Fat and Protein in Livestock Rations

Because the use of fats in various animal feeds has become increasingly popular, we are reviewing some of the latest recommendations and research. The opening article covered poultry: here we discuss general livestock rations.

For Sheep—

There is a limit to the amount of fat sheep will tolerate in their rations. Iowa State College workers reported that 9 per cent fat added to the total ration definitely reduced feed intake, rate of gain, and feed efficiency.

Rather than add fat as such, University of Minnesota workers fed whole soybeans (1) as the only grain, or (2) as 50 per cent of the grain ration. This added approximately 9.0 and 4.5 per cent fat, respectively, to the total ration. Palatability was a problem. In comparison to a corn-alfalfa ration, a decidedly lower feed intake, rate of gain, and feed efficiency occurred at both levels of the soybeans.

However, few sheepmen will buy a complete feed (roughage and grain), and farmers will not feed soybeans as a substitute for corn to sheep. Protein supplement is the main feed purchased.

What about higher fat levels in the protein supplement? University of Minnesota workers have conducted several trials in which soybean oil meal with 10 per cent added animal fat (total ration contained about 1.0 per cent added fat) was compared on a pound-for-pound basis with ordinary solvent-extracted soybean meal. South Dakota State College workers replaced soybean meal with whole soybeans as the protein supplement, resulting in the total ration deriving 1.5 to 2.0 per cent fat from the beans. The results in both of these tests were comparable with solvent-extracted meal.

Under practical feed manufacturing conditions, 10 per cent is the maximum amount of fat that can be added to a feed. If a protein supplement with 10 per cent added fat were fed in the usual manner, the total ration would then contain about one per cent added fat.

The sheepman views protein supplements with added fat as a dust-free feed that, in some instances, reduces the necessity of pelleting. Research indicates he can expect as good results from it as the usual supplement. Feed manufacturers may find difficulty with the keeping qualities of protein supplements that contain more than 5 to 6 per cent added animal fat. Its appearance and handling qualities, however, should give it added selling appeal.

—R. M. Jordan, Assistant Professor of Animal Husbandry.

For Pigs—

Corn and oats are the principal grain ingredients in swine rations in this area. Corn has about 3.8 per cent fat and oats 4.6 per cent. Thus, any ration based on these grains will have between 3 and 4 per cent fat, even if the other ingredients used contain no fat. The minimum requirement of the pig for fat has not been determined, but it appears to be in the neighborhood of 0.1 per cent of the total diet. Therefore, commonly fed swine rations should be completely adequate in fat content.

The value of adding stabilized fat to ordinary swine rations, from weaning to market weight, has been studied.

At Purdue, stabilized lard was added at levels of 1, 2, 3, 4, 6, 8 and 10 per cent. None of these additions increased rate of gain. Levels of 1 to 4 per cent had no effect on feed efficiency. The higher levels decreased feed requirements 7 to 10 per cent per pound of gain.

In Florida experiments, levels of 10 and 15 per cent added waste beef fat increased feed efficiency so that 100 pounds fat had a value equal to 115 pounds of yellow corn.

In a North Carolina experiment, 10 per cent of added beef fat or 10 per cent commercial grease increased gains about 0.10 pound per pig per day and reduced feed requirement per pound of gain about 16.5 per cent.

In Minnesota studies with pigs weaned at 3 weeks, the addition of 5 per cent fat to the ration did not affect rate of gain but decreased feed required per pound of gain slightly.

In these and other studies reported, the addition of fat has not appreciably affected the rate of gain. The value of the fat additions, in terms of improvement in feed efficiency, has been calculated—assuming a value for corn of $1.25 per bushel, and with a standard supplement at $5.00 per 100 pounds. On this basis, the added fat was worth 3.4 cents per pound in the Florida experiment, 7.75 cents in the North Carolina experiment, and 3.6 cents in Minnesota.

An average ration for pigs from weaning to market weight is about 85 per cent corn (or corn and oats) and 15 per cent supplement. The addition of significant amounts of fat to such a ration, via the supplement, is not feasible. It appears, therefore, that unless the swine producer buys complete mixed rations, the outlet for surplus fat in swine feeds is quite limited in Minnesota. Under Minnesota conditions, the purchase by the farmer of complete rations appears quite impractical at the present time.

—L. E. Hanson, Professor of Animal Husbandry.

For Beef Cattle—

The use of beef tallow in cattle fattening rations is a recent development. J. Matsuchima and associates have conducted several feeding trials at the University of Nebraska Experiment Station in which they showed that beef tallow can be fed as a source of energy to fattening cattle, especially when the ration is composed of feeds low in plant fat. In 1955, after the conclusion of three feeding trials in which varying amounts of edible and inedible beef tallow were added to standard Corn Belt fattening rations, they made the following observations:

1. Results were satisfactory when not more than one pound of inedible fat was added per head daily.

2. High grade *inedible* beef tallow was utilized just as effectively as high grade *edible* tallow.

3. Energy from high grade inedible tallow was used almost as effectively as the energy from corn when the level of tallow did not exceed one pound.

4. On the basis of these experiments, it would not be economical to pay more than 2.5 times the cost of ground shelled corn for each pound of animal fat.

5. No digestive disturbances occurred when the consumption of beef tallow did not exceed one pound per head daily.

6. When consumption of beef tallow did not exceed one pound per head daily, there were no apparent differences in the color or hardness of the carcass fat. There was little or no difference in dressing percentage or carcass grades.

—A. L. Harvey, Professor of Animal Husbandry.

For Dairy Cattle—

In recent years, two things have stimulated interest in the possibility of utilizing animal fats in dairy herd rations. One is the large amount of fats available at relatively low prices. The other is the effect which increasingly efficient fat-extraction methods have had on meals—where formerly meals contained 5 to 8 per cent fat, they now contain only 1 or 2 per cent.

It is possible, therefore, that some dairy rations may not be providing enough fat, even when fed with liberal amounts of good quality roughage that normally contains 2 to 3.5 per cent fat. H. Wenzel Eskedal, after studying the

(Continued on page 7)

Mixtures of Agricultural Chemicals

LAURENCE K. CUTKOMP, T. H. KING, and JOHN M. MacGREGOR*

The use of mixtures of agricultural chemicals—insecticides, fungicides, herbicides, and fertilizers—has become increasingly popular in the past few years. In this article we report on some of the recent research and developments in the field.

Insecticide-Fungicides

The use of mixtures of an insecticide and a fungicide has been going on for many years, particularly in phases of agriculture involving fruit production and commercial growing of potatoes. The serious attack of both insects and plant diseases made the use of this pesticide combination a necessity to save time and labor. The somewhat limited amount of research accompanying the commercial practice was centered about the compatability of the chemical mixtures. Very few studies concerned themselves with production of quality fruit.

Since World War II the use of different mixtures has notably increased.

Seed Treatment

The insecticide-fungicide mixtures are becoming fairly well established for treatment of seeds, especially corn and small grains but also for many other seeds. This became a reality because effective insecticides were found. The principal insecticides used are dieldrin, lindane, heptachlor, and aldrin. Fungicides had been used alone as seed treatments for more than two decades.

Application on Plants

Whether insecticides or fungicides are being used alone or in combination, be sure to read the label carefully. The label will tell how to use the chemical safely and effectively.

Plant injury as a result of the application of individual chemicals for the control of insects and diseases depends on a number of factors, including these:

1. The chemical may have inherent toxicity to specific plants and parts of plants or even a specific variety.

2. Temperature may be responsible for stimulating chemical injury. Many chemicals are perfectly safe when applied to plants if the temperatures remain at 85° F. or below.

Combinations of chemicals may cause plant injury. This is one of the types of plant injury that, if sufficient research has been done, can be avoided by the grower. Injury may occur as a result of a combination of fungicides and insecticides, or as a result of a particular fungicide being applied some days following another particular type of fungicide. Examples of some combinations that are the cause of injury follow:

Incompatability of Fungicides—Recent reports indicate that captan (Orthocide 50W) applied to apples immediately following a sulphur spray will cause injury such as leaf spotting, yellowing, and dropping of leaves. This injury seems to be specific with certain varieties.

Incompatability of Fungicides with Insecticides—One of the best known types of injury resulting from a combination of insecticide with funigicides is the liquid lime sulphur-lead arsenate combination. Wherever lime sulphur is used with lead arsenate additional lime must be applied to make the mixture safer and to cut down the arsenical injury. In recent years it has been determined that wherever lime sulphur is used, injury will result if any of the following insecticides or miticides are combined with it: DDT, dinitro (dry mix No. 1), DMC [di(p-chlorophenyl) methyl carbinol] (Dimite), ovex (Ovotran), parathion, Tepp, EPN, and malathion.

In addition some states have reported injury when parathion or DN-111 was combined with Tag (mercury). The mercuries in general may cause some injury to specific varieties of apples, and the insecticides parathion and DN-111 seem to increase the foliage injury caused by Tag. In addition, Karathane has been reported to increase mercurial injury.

Whenever Glyodin (Crag 341) has been used with lead arsenate, arsenical injury has resulted on certain susceptible varieties such as Cortland and McIntosh. Many states have reported this type of injury, and recent results indicate that where fresh hydrated lime is added to this combination at the same rate as the lead arsenate there has been a reduction in the russetting injury to the fruit.

These are a few examples of some of the injury that results from various combinations of chemicals. **Again, reading labels can avoid many of these injuries where combinations work well in one circumstance and not in another.**

* Laurence K. Cutkomp is associate professor of entomology; T. H. King is associate professor of plant pathology; and John H. Mac Gregor is associate professor of soils.

Insecticide-Herbicides

Insecticide mixtures with herbicides represent a fairly recent advance. Grasshopper control and weed spraying along roadsides have been carried out with mixtures of chlordane, toxaphene, or dieldrin plus 2,4-D. The use of such mixtures has been extended to some field crops. However, in such cases the user is in a more precarious position, since there is little research to indicate what effect the combination might have on the crops.

Other combinations such as broadcast treatment which includes an insecticide for cutworm control and a pre-emergence herbicide are also quite feasible, provided the effect of the combinations are carefully evaluated.

Fertilizer-Insecticides

The greatest development in the use of mixtures of different types of chemicals has been with fertilizers and insecticides. Fertilizers have also been used with the herbicide, 2,4-D, but this combination has not been used as widely.

The estimated use of such mixtures in 1953-54, involving primarily insecticides with fertilizers, amounted to 149,000 short tons in the United States and Puerto Rico, according to the Agricultural Research Administration, U. S. Department of Agriculture. In 1955 this figure increased 33 per cent more to about 200,000 tons.

Greatest use in 1954 was in the South Atlantic states of Florida, Georgia, North and South Carolina, and Virginia with 73,200 tons. The west North Central states including Iowa, Kansas, Minnesota, Missouri, Nebraska, and the Dakotas ranked second using an estimated 42,600 tons in the same period. This is a phenomenal increase from 2,000 tons used in the west North Central states area in 1952-53.

The greatest use has been on corn land, with potatoes ranking second.

Compounds Used—The principal insecticidal compounds in descending order of frequency, recommended for inclusion of fertilizers to control soil insects, are: aldrin, heptachlor, chlordane, dieldrin, and DDT. Most of these form a usable emulsion with liquid mixed fertilizers. On the whole these compounds are recommended to aid in the control of 25 kinds of insects on some 35 different crops.

The control of wireworm and corn rootworm infestations on corn land and white grubs and several maggots is a major objective of these mixtures in several states. The recommended acre rates of application in the different states range from 0.5 to 4 pounds for aldrin, dieldrin, and heptachlor; and 0.5 to 10 pounds for chlordane. These rates depend upon the state, the kind of soil,

(Continued on page 7)

Use of Trace Minerals in Livestock Rations

Editor's Note—Here is the third in a series of discussions on the place of specific minerals in the feeding of livestock.

For Poultry—

The suggested mineral allowances for poultry have been static for a considerable time. It is commonly felt that the mineral levels suggested by the National Research Council in 1954, listed in the table, are adequate for poultry rations. It is not the writer's intent in this article to make any suggestions for change in the accepted requirements, but merely to point out some of the problems in providing minerals for poultry in relation to sources of minerals and variations in diets.

Additional mineral requirements are known for the chick. These include a recommended level of 9.0 milligrams of iron and 0.9 milligrams of copper for each pound of ration. Zinc, aluminum, molybdenum, nickel, and cobalt are also routinely added to purified diets—although little is actually known regarding specific requirements for these and other trace minerals. The study of trace minerals has been difficult, because of the presence of many different minerals in all of our natural feed ingredients. This has led to the inevitable dependence on our natural ingredients to supply adequate amounts of trace minerals. Commercial trace-mineral mixes are available which include additional quantities of various mineral elements besides those listed in the table at the right.

Current research demonstrating the growth-promoting properties of the ash of various feed ingredients raises the immediate question of whether we have adequate knowledge concerning the mineral requirements of poultry. It is conceivable that minerals may be required that have been ignored in previous ration formulation. It is also true that a balance of mineral elements may be the explanation of the response to the ash of certain ingredients.

These developments leave us somewhat in the dark regarding definite quantities of all mineral elements to suggest for poultry rations. It is obvious that increased research is needed to further our knowledge regarding specific mineral requirements and any interaction affecting other dietary considerations. However, the presently accepted allowances can be followed until more information suggests specific changes.

—**Elton L. Johnson, Professor and Head, Poultry Department.**

For Sheep—

Higher rates of production and depleted soils due to intensive cropping, inadequate fertilization, and soil erosion have increased our concern about the trace mineral needs of sheep.

Iodine is a "must" for breeding livestock in Minnesota. Usually it is obtained through iodized salt.

Cobalt is essential for the health of rumen bacteria, blood formation, and B_{12} formation. Lack of cobalt results in anemic, undernourished sheep that have no appetite and are very susceptible to internal parasites.

Copper, iron, zinc, and manganese make up the balance of the group commonly referred to as trace minerals. Their role in animal nutrition is as vital as cobalt or iodine, but deficiencies of them are less likely in Minnesota.

Generally speaking, good quality roughages contain a greater amount of the trace minerals than the grains. However, low quality roughages are low in trace minerals. The Ohio Experiment Station obtained significantly greater weight gains when they added a complete trace mineral salt or cobalt to low quality roughage rations (corn cobs).

Soil tests at the University of Minnesota and practical feeding demonstrations in the state indicate that cobalt is the trace mineral most likely to be lacking—particularly on sandy soils—and will result in the greatest increase in production when added to cobalt-low rations.

Providing trace-mineral salt free-choice, in addition to plain iodized salt, is a cheap and effective way to assure adequate trace mineral intake. This method will avoid any danger of excessive intake. The cost is very little more than iodized salt, and it may aid in the efficiency of production.

—**R. M. Jordan, Assistant Professor of Animal Husbandry.**

For Beef Cattle—

Trace minerals needed by beef cattle are usually supplied in sufficient amounts by natural feeds, except iodine and possibly cobalt.

Iodine should be supplied because Minnesota lies in a semi-goiterous area and the feeds commonly fed are apt to be deficient. W. B. Griem and his associates at the University of Wisconsin (1942) recommended the use of iodized salt containing .01 per cent iodide (0.0076 per cent iodine) stabilized to prevent loss of iodine. Allowing cattle to have free access to iodine, combined with common salt either in block or loose form, has proved to be a very effective way of supplying their needs. Lack of iodine will cause enlargement of the goiter, often called "big neck", and result in metabolic disturbances.

Cobalt may be lacking in a few areas in Minnesota. If such a condition prevails, the most practical procedure would be to allow cattle to have free access to trace-mineralized salt for-

(Continued on page 6)

MINERAL ALLOWANCES FOR POULTRY

Chickens	Starting chickens, 0-8 weeks	Growing chickens, 8-18 weeks	Laying hens	Breeding hens
Calcium, percent	1.0	1.0	2.25*	2.25*
Phosphorus, percent†	0.6	0.6	0.6	0.6
Salt, percent‡	0.5	0.5	0.5	0.5
Potassium, percent	0.2	0.16	?	?
Manganese, mg.	25	?	?	15
Iodine, mg.	0.5	0.2	0.2	0.5
Magnesium, mg.	220	?	?	?

Turkeys	Starting poults, 0-8 weeks	Growing turkeys, 8-16 weeks	Breeding turkeys
Calcium, percent	2.0	2.0	2.25*
Phosphorus, percent§	1.0	1.0	0.75
Manganese, mg.	25	?	15
Salt, percent‡	0.5	0.5	0.5

* 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.

† At least 0.45 percent of the total feed of starting chickens should be inorganic phosphorus. All of the phosphorus of non-plant feed ingredients is considered to be inorganic. Approximately 30 percent of the phosphorus of plant products is non-phytin phosphorus and may be considered as part of the inorganic phosphorus required. A portion of the phosphorus requirement of growing chickens and laying and breeding hens must also be supplied in inorganic form. For birds in these categories the requirement for inorganic phosphorus is lower and not as well defined as for starting chickens.

‡ This figure represents salt or sodium chloride added as such or in marine or fermentation products of high sodium chloride content.

§ At least 0.50 percent of the total feed of starting poults should be inorganic phosphorus. All of the phosphorus of non-plant feed ingredients is considered to be inorganic. Approximately 30 percent of the phosphorus of plant products is non-phytin phosphorus and may be considered as part of the inorganic phosphorus required. Presumably a portion of the requirement of growing and breeding turkeys must also be furnished in inorganic form.

(Continued from page 5)

tified with cobalt. Recent experimental work indicates that some of the trace minerals may be needed, not so much by the cattle as by the rumen bacteria. There is considerable evidence that cobalt is essential for the production of vitamin B_{12} by micro-organisms of the rumen.

—**A.L. Harvey, Professor of Animal Husbandry.**

For Pigs—

Iron and copper for the baby pig, iodine for swine of all ages, and zinc for growing pigs are the trace minerals of most practical importance in Minnesota swine rations.

Suckling pigs develop anemia, unless iron and copper supplements are provided until the pigs are eating starter or other creep feeds *well*. Fortunately, many crude iron compounds contain sufficient copper as an impurity so that no attention needs to be given to copper. We use crude iron sulfate ("Copperas") and mix 1 pound in ½ gallon of water. The sows' udders are swabbed daily with this solution, starting when the pigs are 3 or 4 days of age and continuing for about 3 weeks. Any pig starter or creep feed made of the usual feed ingredients will provide the needed iron and copper, after the pigs have learned to eat it.

Iodine is especially important in breeding rations of pregnant females. The use of stabilized iodized salt which contains 0.007 per cent iodine at a level of 0.5 per cent in the total ration will fully meet the needs of swine of all ages for this element.

The minimum requirement for zinc is unknown. In Minnesota experiments, the addition of 22 p.p.m. of elemental zinc per pound of feed has cured parakeratosis in pigs, produced by feeding excess calcium. Pigs which developed parakeratosis on normal calcium rations recovered promptly when 11 p.p.m. of zinc was added per pound of feed. Parakeratosis has not been reported in swine of older ages. Manganese is known to be required by the pig. This requirement appears to be wetween 12 to 40 p.p.m. Most good swine rations should be adequate without supplemental manganese.

No one has succeeded in producing a cobalt deficiency in growing pigs, even by using highly purified diets, when the ration contains adequate vitamin B_{12}. Since vitamin B_{12} is a well established necessity in the pig's ration, it is usually included.

Potassium is infrequently classed as a trace mineral. Normal growth is produced when rations contain 0.23 to 0.28 per cent potassium. Since corn contains this amount and other cereals and feeds contain even more, there is no need for adding potassium to swine rations.

The various trace-mineral premixes that are commonly added to swine feeds appear to be entirely adequate, when used according to the manufacturer's recommendations. The possible exception was zinc and some, if not all, premixes now have increased zinc levels. Trace-mineralized salt has been adequate except for zinc. The brands with which the writer is familiar contained 0.005 per cent zinc. Whether or not this level has been increased recently is not known to the writer.

—**L. E. Hanson, Professor of Animal Husbandry.**

For Dairy Cattle—

Iodine, cobalt, iron, copper, manganese, and zinc are the elements commonly spoken of in animal nutrition as the "trace minerals." Experiments have shown that dairy cattle need them all for complete nutrition, but information is very incomplete as to the amounts of each required. In all cases, however, the amount is exceedingly small. For example, a cobalt level of one-tenth part per million in the ration will provide adequate amounts of that element.

Little is known as to the exact role of the trace minerals in the animal body. Apparently, however, they perform important regulatory functions and are especially necessary in connection with blood formation. They may also have added significance in ruminant metabolism, because of their evident influence on the activity of the rumen micro-organisms.

Dairy herd rations made up of high-quality feedstuffs and which supply enough of all other nutritional factors will usually provide enough of the various trace minerals. However, if the feeds were grown on soils poor in one or more of these elements, deficiencies may occasionally occur.

Iodine—In the states in the Great Lakes Region, soil is known to be poor in iodine. Here rations often fail to provide enough iodine, and numerous cases of goiter in newborn calves occur in dairy herds if an iodine supplement is not provided. Iodine affects the functioning of various glands in the body. In particular it affects the thyroid, which secretes the hormone thyroxin, the regulator of the rate of body metabolism. Greatest demand for iodine, and perhaps for some of the other trace minerals also, is during pregnancy. As yet, however, no positive relationship between the iodine content of the ration and reproduction in cattle has been established. It may be assumed that no iodine deficiency exists, except when goiter occurs in animals on the farm.

Cobalt—A survey made by the author of the cobalt content of crops grown in Minnesota suggests that this element may also, occasionally, be in deficient supply in dairy rations. Many borderline cases of cobalt deficiency, and some severe ones, have been observed in the region—especially in sandy soil areas where much of the cobalt salts have apparently been leached out. Only ruminants appear to require cobalt, and its mode of action is not fully understood. The theory is that it is required by the micro-organisms for vitamin B_{12} synthesis.

The symptoms of cobalt deficiency in cattle are well defined. Invariably, affected animals are listless and show a loss of appetite, a marked decrease in milk flow, and general emaciation. The hair coat is rough, and it may not be shed until late in the season. Blood hemoglobin is only about one-half to two-thirds of normal.

Other trace minerals—No clear-cut evidence of a deficiency in any of the other trace minerals has been observed in dairy herd rations in Minnesota. Studies at the Ohio Agricultural Experiment Station, however, suggest that they may occur on farms where poor quality roughage forms a major portion of the ration. Other conditions may also cause various trace mineral deficiencies. **It should be emphasized that a trace mineral supplement feed with poor quality roughage will not wholly replace good quality roughage.**

From these facts, it is evident that a feeding program which includes feedstuffs grown on soil poor in any of the trace minerals—or which has poor quality roughage making up a major portion of the rations—might occasionally be deficient in one or more of the trace minerals. This suggests the need of providing a proper supplement to insure against possible deficiencies.

Such a supplement can be provided in a variety of forms and ways. It is probable, however, that trace-mineralized salt will prove both the simplest and best for the purpose. Because it involves such very small amounts of the various elements, it is usually preferable to use one of the good commercially prepared trace-mineralized salts instead of trying to weigh and mix the supplement on the farm. Information is still incomplete as to the amounts of each mineral that should be included in such a salt. And it should be emphasized that there is about as much danger of including too much as too little.

Trace-mineralized salt can be fed free-choice in a salt box or at the rate of 0.5 to 1.0 per cent of the concentrate mixture. Claims made that feeding trace-mineralized salt to cattle tends to make them resistant to various diseases have largely been disproved.

—**Thor W. Gullickson, Professor of Dairy Husbandry.**

FAT AND PROTEIN FOR LIVESTOCK

(Continued from page 3)

effects of different levels of fat in dairy rations in Denmark, where solvent-extracted meals provide a large proportion of the nutrients, concluded that Danish cows have for a number of years received too little fat in their rations.

Experiments have established that dairy cows require a minimum level of fat in their rations for well-being and optimum milk secretion. Workers are not in agreement, however, on what is the most desirable level, nor on the effects of different levels on the cow and on her milk and fat production.

Ohio workers reported no consistent differences in milk and butterfat production or general performance between grain mixtures with fat contents ranging from 2.7 to 5.0 per cent. At the Michigan Experiment Station, as well as at the University of Minnesota, it was found that the addition of soybean oil to the basal ration resulted in a pronounced but very temporary increase in the fat percentage of the milk.

L. A. Maynard and his associates at Cornell University found that a low-fat dairy ration produced a marked decrease in milk volume, with no change in the percentage of fat in the milk, while rations in which fat was replaced with isodynamic amounts of starch produced milk of lower iodine number. He concluded that a concentrate mixture containing 4 per cent of plant fat is satisfactory, when fed with good quality roughage at the rate of 1 pound grain for every 3 to 3.5 pounds of milk produced daily.

An experiment was recently conducted by the author at the Minnesota station to ascertain the extent to which stabilized animal fats may be added to the grain mixture of dairy heifers, and the effect on rate of gain in weight, reproduction, size and vigor of calves, and milk and fat production.

Four sets of identical twin heifers were used. One from each set was fed a grain mixture of natural fat content, and the other a similar mixture with stabilized animal fat added. The results showed that animal fats in amounts up to 10 per cent by weight could be included in the concentrates mixture without seriously affecting its palatability. However, one Guernsey heifer refused to eat grain which had any animal fat added.

In the heifers that ate the fat-enriched mixture, it had no noticeable effect on appearance of animals, the size and vigor of their calves at birth, nor on the amount and fat content of the milk produced. The only value of the added fat apparently was as a source of energy.

In other experiments, the author found that young calves invariabily will die within a few weeks if fed vegetable oils (such as those from corn, cottonseed, peanuts, coconuts, soybeans) homogenized with skimmilk, even at 1.5 per cent level. Fair to good results may be obtained when animal fats and hydrogenated vegetable fats are used in the same manner.

In an experiment recently reported by W. B. Nevens at the University of Illinois, it was shown that dairy cows can use up to two pounds of stabilized animal fat per head daily, to replace energy supplied by other feeds. He fed 15 per cent protein concentrate mixtures containing 4, 8 and 12 per cent fat. The three mixtures contained 0.0, 3.5, and 8.5 per cent of stabilized fat respectively. The mixtures were fed with various kinds of roughage—including medium-quality alfalfa hay, corn silage, and Sudangrass pasture.

No great difficulty was encountered in getting cows to eat any of the mixtures, although a few cows were a bit slow on the mixture with the highest fat content. Also, in no case were there abnormal physiological effects from feeding the fat-enriched rations, nor were there any differences between groups in the amounts of milk and fat produced and the percentage of fat in the milk. Neither were there any significant differences in the composition of the fat, nor in the Vitamin A value of the milk produced.

Nevens points out that it is unlikely that stabilized animal fat will become a usual replacement for corn or other energy-rich feeds in dairy herd rations: The foregoing results, however, suggest that such replacements might be made to advantage in rations of high-producing cows when the cost of the stabilized fat is less than 2.25 times that of corn or other farm grains.

It should be explained that stabilized animal fat means inedible or waste tallow, lard, and grease from meat packing plants which have been treated to prevent the fat from becoming rancid.

—**Thor W. Gullickson, Professor of Dairy Husbandry.**

AG CHEMICALS

(Continued from page 4)

insect, crop, and the method of application (row or broadcast; surface or worked in).

University of Wisconsin experiments on a field in its fourth year of corn, in 1955, showed that one-half pound of aldrin or heptachlor per acre, mixed with 5-20-20 and used as a starter fertilizer, provided a high degree of plant protection against the corn rootworm *Diabrotica longicornis.* One-half pound of aldrin per acre reduced corn lodging 70 per cent and increased yield 28 per cent, while the same rate of heptachlor reduced lodging 91 per cent and increased corn yield 34 per cent.

Aldrin-fertilizer mixtures have been effective in control of wireworm when applied with small grain seed.

The ultimate use of insecticide-fertilizer mixtures will be affected by total fertilizer sales since investigators have shown an ever-increasing need for the destruction of soil insects. Fertilizers, whether spread broadcast or used as a starter, provide an excellent carrier for these insecticides.

Many combinations of insecticides and fertilizers are sacrificing some efficiency in favor of one agent or the other. However, the labor-saving aspect has forced many other considerations into the background, at least in the beginning stages of the widespread usage.

A very striking feature of the fertilizer-insecticide usage is that extremely little research data has been published to indicate the comparative value of the combinations versus the chemicals applied separately. Consideration has chiefly centered about immediate compatability.

One experiment is planned by the University of Minnesota for this season to compare a liquid and dry insecticide-fertilizer formulation alongside the materials used separately. Insect control and yield and quality of sweet corn will be evaluated.

Fertilizer-Trace Elements

In areas where any one or more of the trace elements (boron, copper, iron, manganese, molybdenum, and zinc) are not sufficiently available in the soil for normal plant growth, it is common practice to mix them with solid fertilizer materials in the fertilizer mixing process. In this way both trace elements and fertilizer can be applied in a single operation.

It is easy to include trace elements in liquid mixed fertilizers, but as in the case of the solid fertilizers, it results in a slight decrease in the concentrations of the major fertilizer nutrients present. This decrease can be readily overcome by applying the fertilizer-trace element mixture at only a slightly heavier rate.

At the present time, however, crop production in Minnesota does not usually require the application of trace elements, with the exception of a few specialized crops in limited areas. If trace element needs become more widespread, application with fertilizer will be relatively simple and inexpensive.

Fertilizer May Increase Soybean Yields

JOHN M. MacGREGOR and HAROLD E. JONES*

Soybeans yield better on fertile, well-managed soils—especially if sown following a crop that is usually fertilized, such as corn. Until the last few years, the direct application of fertilizer for soybeans has not usually been profitable. A 25-bushel per acre soybean crop requires 125 pounds of nitrogen, 40 pounds of phosphate, and 60 pounds of potash.

Since soybeans are a legume, most or all of the nitrogen is obtained from the air, provided that the soil is not too acid and nodulation of the roots in the soil occurs. However, soybeans must remove the minerals phosphate and potash from the soil to grow well, and eventually this supply of available mineral nutrients may become depleted.

During the past few years, the direct application of fertilizers has substantially increased some soybean yields. This could be expected since some of Minnesota soils have now been farmed about 100 years.

Two examples of soybean response to direct fertilization—one on a fine-textured and one on a sandy soil—may well illustrate that the soybean plants are having increasing difficulty in obtaining adequate nutrients for the production of maximum yield.

In 1954, soybeans were planted on a Waukegan silt loam on the University of Minnesota Agricultural Experiment Station, Rosemount. The soil was acid with a pH of 5.5, and the supply of available phosphate and potash was medium. Starter fertilizer (6-24-12 at the rate of 170 pounds per acre) was applied along the row on most of the field. However, on a number of rows near the middle of the field, the starter fertilizer was omitted.

The differences in the soybean growth between the fertilized and the unfertilized soybeans was evident during the entire growing season (figure 1). The eventual unfertilized soybean yield was 22 bushels per acre, whereas the fertilized yield was 26 bushels. Since only a complete fertilizer was used, it is not possible to conclude which nutrient or nutrients were responsible for the growth differences, but a mineral deficiency may be suggested.

Fig. 1. Effect of starter fertilizer (as listed on the board at left) on soybean growth at Rosemount, 1955. Soybean rows at the right were not fertilized.

In 1955, a field of Anoka loamy fine sand in southern Isanti County on which soybeans previously, and frequently, had been grown was again planted to this crop. The pH of this soil was 5.7, and it was high in available phosphate and low in available potash. Total organic matter was only 1.2 percent, which is a characteristic of sandy soils. Different fertilizer treatments were applied, such as nitrogen and potash alone as well as combinations of nitrogen-potash and phosphate-potash.

Table 1. The effect of fertilizing soybeans on Anoka loamy fine sand, 1955

Nutrients applied			Soybean yield
N	P_2O_5	K_2O	
(pounds per acre)			(bushels per acre)
0	0	0	16.0
40	0	0	16.8
0	0	60	22.3
0	60	60	21.2
40	0	60	24.8

The soybean growth on the treatments containing potash was considerably healthier than on those treatments where the potash was omitted. The resulting yields for the different treatments are shown in table 1.

It is evident that the application of potash was the most effective single nutrient for increasing yield, although the nitrogen-potash combination produced the largest increase. Since sandy soils are usually not well supplied with potash, deficiencies of this nutrient could be expected after a few years of cultivation. On extremely acid soils where nodulation is limited or does not occur, soybeans, even though a legume, could respond well to nitrogen applications.

It is suggested that every Minnesota farmer planting soybeans will do well to try a little complete fertilizer on at least a few rows in each field. He can then satisfy himself whether soybeans growing on his fields are in need of fertilizer, specially if his soil tests acid and low in available mineral content.

* John M. MacGregor is associate professor of soils, and Harold E. Jones is extension soils specialist.

1956 Animal Nutrition Short Course

September 10-11 will be the dates of the 1956 Animal Nutrition Short Course on the University's St. Paul Campus. Write the Short Course office, 207 Coffey Hall, for details.

UNIVERSITY OF MINNESOTA, INSTITUTE OF AGRICULTURE, ST. PAUL 1, MINN.

Cooperative Extension Work in Agriculture and Home Economics, University of Minnesota, Agricultural Extension Service and United States Department of Agriculture Cooperating, Skuli Rutford, Director. Published in furtherance of Agricultural Extension Acts of May 8 and June 30, 1914.

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