UNIVERSITY OF MINNESOTA
DEPARTMENT OF AGRICULTURE
AGRICULTURAL SHORT COURSES

ANIMAL NUTRITION

SHORT COURSES

FOR

FEED MANUFACTURERS AND DEALERS

OCTOBER 25, 26, 1948

AUDITORIUM, ADMINISTRATION BLDG.

UNIVERSITY FARM, ST. PAUL

Stop

PROGRAM

Monday, October 25, 1948

Auditorium, Administration Bldg.

W. H. Peters, Presiding

A.M.		
9:00	Registration	
10:00	The Livestock and Feed Situation	
	For Dairy Cattle	Ralph Wayne
	For Poultry	Cora E. Cooke
	For the Meat Animals	H. G. Zavoral
12:00	Lunch	

J. B. Fitch, Presiding

P.M.		
1:15	Opportunities and Problems of the Feed Industry	L. H. Patten
1:45	Recent Developments in Swine Nutrition	R. M. Bethke
2:30	Feeding Thyroprotein to Dairy Cattle	L. A. Moore

Tuesday, October 26, 1948

M. O. Schultze, Presiding

A.M.		
9:00	Trace Elements in Poultry Nutrition	G. M. Briggs
10:00	Dairy Cattle Nutrition Research at Beltsville	L. A. Moore
11:00	Medicated Animal and Poultry Feeds from the Standpoint of the Federal Food, Drug, and Cosmetic Act	H. E. Moskey
12:00	Lunch	
P.M.		
1:15	The Relation of Nutrition to Hatchability and Early Chick Growth	R. M. Bethke
2:00	Some Modern Swine Management and Feeding Practices	Damon Catron
2:45	Trends in Fundamental Nutrition Research	M. O. Schultze

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*C. H. Bailey, Dean and Director, Department of Agriculture

*J. O. Christianson, Director, Agricultural Short Courses

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*G. M. Briggs, Assistant Professor, Division of Poultry Husbandry

Damon Catron, Assistant Professor, Animal Husbandry, Iowa State College, Ames, Iowa

*Cora E. Cooke, Assistant Professor, Agricultural Extension Division

*J. B. Fitch, Professor and Chief, Division of Dairy Husbandry

L. A. Moore, Head, Section of Dairy Cattle Nutrition, Washington, D. C.

H. E. Moskey, Chief, Veterinary Medical Section, Food and Drug Administration, Washington, D. C.

L. H. Patten, General Manager, Farmers and Merchants Milling Company, Glencoe, Minnesota

*M. O. Schultze, Professor, Division of Agricultural Biochemistry

*Ralph Wayne, Assistant Professor, Agricultural Extension Division

*H. G. Zavoral, Associate Professor, Agricultural Extension Division

* University of Minnesota

PROGRAM COMMITTEE

W. H. Peters, E. F. Ferrin

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THE DAIRY FEED SITUATION

Ralph W. Wayne
Assistant Professor, Agricultural Extension, Extension Dairyman
University of Minnesota, St. Paul Campus

Minnesota farmers like those in other areas, are harvesting a record crop of centrated feed-corn and grain. The total production of feed grains in the ted States is 8% above the record of 1946. The concentrate feed supply is 22% r that of last year. The concentrate supply per animal unit is 1.05 tons. The centrates fed per animal unit have run from .74 to .79 in recent years. In nesota, we are producing 30% more feed grains than last year, the highest since 0. A year ago our feed supplies were low because of a small crop. Prices rose-- re was a great world need for cereal grains. Then we were thinking in terms of ing feed--making grains go as far as possible. Now we have an abundant supply of centrates, particularly corn and grain. The picture is quite the reverse of last r. Dairymen are now asking how much grain they can feed and still get more than market price.

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Dairy cow numbers have been decreasing since 1944. We now have 12% less milk s and heifers over 2 years old than four years ago, or about the same number as fore 1940. It is anticipated that this reduction may continue into 1949. In our tion of the country, the reduction has been even greater. In the north central ates the peak in cow numbers was reached in 1943. It has since declined 20% to a el 13% below prewar and the lowest in 26 years. This reduction has come mostly marginal dairy areas where farmers found they had more returns for their labor m raising corn, soybeans, and grain than milking cows. High beef prices also ntributed to reduction of dairy herds. Along with a decrease in cow numbers has me a reduction in total milk production but an increase in production per cow. Last ar we reached 5,000 pounds milk per cow for the first time. This has resulted from lling of the poorer cows in the average and good herds and many of the marginal irymen going out of the dairy business. Now with cheaper feed many of these people e out looking for cows.

The demand for dairy products continues to be good and will continue so for the t year, at least, or as long as we have high incomes of consumers. We cannot rease our milk cow numbers quickly so it will take some time to build up a surplus ply. Americans now are consuming more dairy products per person, with the excep- n of butter. In 1948 we are consuming per capita in terms of milk the equivalent 15% more fluid milk and cream than the average during the years 1935-39, 25% more ese, 22% more condensed and evaporated milk, 4 times as much whole milk powder, 39% less butter. Our per capita consumption of all dairy products in terms of k is 95% of what it was prior to the war. This decline is due largely to butter duction.

Exports of dairy products during 1948 will be about 2.3% of our total produc- on in terms of milk. This compares with 5.3% in the peak year of 1944, and 0.1% 1930-39. Exports this past year have not been as great as were anticipated. is expected that exports of whole milk products will be about the same in 1949, ile that of non-fat milk solids may increase. The world conditions are so

uncertain at present that it is difficult to forecast definitely what the export picture will be in the next year or two. At best, exports account for but a relatively small percentage of our total production. The income of American consumers has a vastly greater effect on demand for and price of our dairy products than do our world outlets.

The market for whole milk will continue to be broad. While utilization of non-fat milk solids may not equal that of war years, it is well above the pre-war period.

Barring unforeseen disturbances of serious unemployment, war or contracted credit, there is little reason to believe dairy prices will average greatly different for 1949 from that of 1948. However, we must not overlook the drop in butter prices during the past 6 weeks when they would normally strengthen. Unless they firm up during the coming months, we may experience further declines during the flush of May and June. Butter is still the barometer of dairy prices.

The dairyman is in a good position providing he has cows capable of good production and he gives them the care they should have. At present feed costs and butterfat and milk prices, if a dairyman cannot make some money, there is a question if he ever will. The butterfat-feed ratio in September was 37.0 here in Minnesota. That is, 1 pound of butterfat will buy 37.0 pounds of feed grain. A year ago this was 23.6, and the ten-year average is 32.4.

If it ever paid to feed dairy cows well, it certainly does now. A dairy cow not worth feeding some grain this winter should be culled.

Roughage is the foundation of any dairy feeding program. It is our cheapest cow feed. The dairy cow has the unequaled ability to take inedible rough feed and convert it into the most highly nutritious of human foods--milk.

Pasture, hay and silage makes up the bulk of our dairy rations in Minnesota. Only one out of each 6 bushels of corn we produce is fed to dairy cattle. The dairyman's job is to take the roughage he has and balance it with home grown grains and purchased concentrates to provide the most economical and efficient ration. If he has plenty of good legume hay his problem is greatly simplified. Most of our dairymen must now get along with the roughage they have on hand which unfortunately in many cases is of relatively poor quality for milk cows. This is especially true this year.

Since roughage is the foundation of a dairy ration, one must start with the roughage available in working out a feeding program. These feeding programs can be divided into three groups depending on the hay fed. These are:

High protein or good quality legumes.	Medium protein or mixed hay.	Low protein or grass hays.

Where plenty of good quality clean legume hay, mainly alfalfa, is fed (at least 15 pounds a day) Holsteins can produce up to 18 pounds and Guernsey and Jerseys 15 pounds of milk daily on roughage alone. Only home grown grains need be fed for each 2 pounds of milk above these levels of production. This procedure has been followed with good results. However, this year 10% of high protein concentrate in the grain mixture may be desirable. This is urged because butterfat prices are still well above the normal relationship with the price of oil meals. This year we should be very sure we have ample protein in our rations. Dairymen may be short of legume hay this year and feed less of it substituting a roughage such as corn fodder or more silage, both of which are low in protein. 10 - 15% of high protein feed along with grain makes about a 14.0% protein grain mixture.

Census figures show about 35% of this year's hay supply is alfalfa. The balance falls into two other classes. Where a dairyman is feeding mixed hay, legume and grass the grain mixture should be made up of one part of high protein concentrate and four parts of home grown grain. This will make a grain mixture containing about 16% crude protein.

THE DAIRY FEED SITUATION

Ralph W. Wayne
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Where low protein hays are fed the dairyman must provide a large part of the protein from purchased high protein concentrates. These hays vary a great deal in their total feeding value. They range all the way from good quality upland hay and reed canary and sudan grass down to old-fashioned slough grass, much of which may be lower than straw in feed value. Where the bulk of the ration is made up of these hays or where corn fodder or silage are fed very heavily, the roughage part of the ration is very low in protein. The grain mixture should contain about 20% of crude protein and can be made up of one part of high protein feed to two to three parts of home grown grain.

These mixtures should be fed at the rate of one pound of grain for each 3½ pounds of milk in the case of Holsteins and 3 pounds of milk for Guernseys and Jerseys. These rates of feeding are merely guides. The good dairyman studies his cows and increases or decreases the rates of feeding with response in milk production and condition of flesh of the cow.

One of the places where a lot of dairymen fall down is in their failure to get cows in good condition of flesh prior to freshening. Cows a little on the thin side should be fed 4 - 6 pounds of grain during the dry period to get them in good condition before starting on the next lactation. It will result in greater production for several months. Have plenty of steam when you start the engine. Have your cows in good shape when they start out to produce. The grain mixture fed can be the same as fed to the balance of the herd. Growing heifers should also be kept in good growing condition. If they are thin, they should get some grain.

In analyzing the quality of his hay, the dairyman must be honest with himself and in turn with his cows. Much hay that is called alfalfa is half June grass or quack grass and so is a mixed hay and should be considered as such in working out a grain mixture to go with it. The quality as affected by stage of cutting, freedom from rain, etc., should also be given consideration.

The matter of feeding dairy cows boils down to a matter of feeding enough feed containing the essentials for efficient production. Next to not feeding enough is the common error of not feeding enough protein. Soybean meal contains enough protein to meet the protein requirements to produce 9 pounds of 3.5% milk, or about 1/3 pound of butterfat. In other words, where 1 pound of soybean meal is added daily to the ration low in proteins of a producing cow, one can on the average expect to increase production about 1/3 pound of butterfat. With 1/3 pound of butterfat now selling for about 25¢ and soybean meal less than 4¢ per pound it is easy to see that a dairyman should make certain to provide plenty of protein in the cows' ration.

For the dairyman who must buy feed it becomes a matter of studying where he will get the most for his money. If he is short of roughage he can usually buy cheaper nutrients in roughage than concentrated feed. This is especially true if he can get good hay close to home. Transporting hay long distances becomes rather expensive. If he is short of hay and can get good legume hay he will also improve the protein picture of his ration.

In areas of the state where there is an abundance of home grown grains and a limited supply of good legume hay, dairymen can best balance the ration through the purchase of high protein concentrates. His selection among such feeds should be determined largely on the basis of cost per pound of digestible protein. Those containing 32% or more crude protein are usually the cheapest source. In sections where farm grains as well as protein rich feeds must be shipped in, dairymen often find a prepared dairy concentrate of 15% or 20% the best for them. This is especially true with owners of small herds.

It is well for both farmers and feed dealers to be familiar with comparative current feeding values of different feeds. Dr. Petersen here at our experiment station has worked out a quick method of making these comparisons. Tables are given in Bulletin 218. Figuring soybean meal at $74.00 per ton and shelled corn at $1.25 per bushel, the following feeds have these values as feed for dairy cows:

Soybean Meal	$74.00
Linseed Meal	65.30
Shelled Corn	1.25
Barley	1.07
Oats	.67
Bran	43.40
Alfalfa Hay	33.62
Prairie Hay	24.00
Corn Silage	8.75

As we pointed out earlier in this discussion, a pound of butterfat will now buy 57% more feed grains than a year ago, and 11% more than the 10-year average. In spite of this favorable relationship there will still be many farmers who will question whether it is going to pay them to feed their cows grain and concentrates this winter. We have here a chart which brings out some rather convincing information. Experimental work has shown that within a cow's ability to produce, on the average over a period of time 2 pounds of milk should result from each pound of grain mixture. If a dairyman has cows that will respond in this manner, it will cost him the following for grain for each pound of butterfat produced. From this you can see that one can practically double his money feeding grain.

One important factor to remember in analyzing current dairy feeding matters is that dairying is a long-time proposition. If one lets cows run behind for awhile one may not get them back even when fed fall rations later on. The effect of today's feeding carries over for months to come.

Feed dealers can render a real service in advising farmers on their feeding problems. In many ways, you are the most influential. You come in more direct contact with the man buying feed. The kind of advice and service you give him will be reflected in the volume of business you do. The better the service, the more the business. It is pleasing to note the close relationship that is growing between county agents and feed dealers in our state. Efficient dairy production means not only good feeding and management but also improving the breeding in the herd through use of superior sires, keeping production records and controlling diseases. The county agent is directly associated with all of the programs. Feed dealers can make themselves closer to the dairyman and his activities by becoming familiar with the dairy extension program in his community.

The progressive farmer today is well informed on his many operations. He knows more about feeding, he grows the new varieties of crops, he understands DDT and 2,4-D. With the growing complexity of the farming business we that are associated with it can profit by being up-to-date on current information.

THE MEAT ANIMAL FEED SITUATION

H. G. Zavoral
Associate Professor, Extension Animal Husbandman
University of Minnesota, St. Paul Campus

The U.S.D.A. crop report shows 1948 as breaking all production records--8 per cent above 1946 high.

Feed supplies for 1948-49 feeding season are at an all-time high.

	1948	1947	10 year average
Corn	3,568 million bushels	2,401 million bushels	2,814
Oats	1,493 million bushels	1,215 million bushels	988
Barley	317 million bushels	279 million bushels	299

The production was made on yield per acre not increased acreages. In 1920 to 1930 the total corn acreage ran about 100 million acres. In 1948 it was 85 million acres. The increased yield is due to improved methods; hybrid seed corn, greater use of commercial fertilizers and improved corn-growing machinery. Of course, a good growing season must not be overlooked.

The large 1948 crop of soybeans, cottonseed, and flax will result in about a 15 per cent increase in cake and oil meal in this country for the 1948-49 feeding period over 1947-48.

Exports of protein feeds are expected to be larger than last year. It is assumed that the supply of protein feed after export will be the same per animal unit as in 1947-48.

Miscellaneous by-product feeds are in larger supply than average; feeds such as wheat mill feeds, rice mill feeds, dried molasses, alfalfa meal, etc.

The total hay supply for this year is the smallest since 1941. There are areas in Minnesota that are short, but on an average there is sufficient forage for the reduced number of livestock.

The feed supply is about the best in history. Prices of grain, as you all well know, have declined sharply and unless something unforeseen happens, may stay close to Government support levels.

With this record supply of feed the livestock-feed price ratio should be favorable.

HOGS

Since hogs consume about ½ of the corn they will be considered first.

The pattern for 1949 hog production seems rather obvious. With the big corn supply to work with, producers will raise all the 1949 spring pigs they can, and follow that with a large fall pig production. The spring pigs will reach the market in the winter of 1949-50, with everyone attempting to get his hogs sold before the main rush gets in.

Early pigs will have an advantage, more so than in recent years. Pigs farrowed in March, kept well and thrifty, and pushed along fast should be in good market condition by October and November, when meat supplies will still be short. Not everyone is in a position to have early pigs. Those with mature enough gilts, and suitable farrowing quarters will have an advantage.

Farmers and consumers are both wondering how fast hog numbers will increase. In 1948 about 82 million pigs were saved in the U. S. from both spring and fall crops. This compares with 84 million in 1947, 83 million in 1946, 86 million in each of 1944 and 1945. Thus normally the changes in numbers are not extreme.

But at the outbreak of the war with huge corn reserves on hand and heavy demand impending, there was a rapid increase in pig numbers. In 1941 there was about a normal crop of pigs--85 million, but in 1942 the numbers shot up to 105 million, and in 1943 to the record breaking total of 121 million. So hog numbers conceivably could jump considerably above normal in 1949. However, it is not likely that they will. For one thing, much of the 1948 corn that will be carried over through 1949 will be under seal and could only be secured at support prices. Producers will also tend to seal their future corn supplies rather than to take chances of overdoing the hog numbers. In addition to the feed prospects, the numbers of sows for farrowing in 1949 will be limited. Present demand for pork, and liberal feed supplies this winter, will invite the sale of all possible hogs now, rather than holding gilts back for farrowing.

Market weights of hogs should be watched this season. Average weights of hogs marketed in the last few years have generally been 20 to 30 pounds heavier than before the war. The postwar demand for meat has made it profitable to continue this practice. In the period of January through April 1948, the average weight of all hogs slaughtered under Federal inspection was about 20 pounds heavier than prewar. With limited numbers of hogs and liberal feed supplies, there will be a tendency to feed to heavy weights, and discounts may be expected. Close attention should be given to market reports and prospective discounts as the feeding season progresses.

BEEF

The cattle feeder of 1948-49 is confronted with this situation--ample corn supplies, fewer hogs, a prospective good market, but high priced feeders.

Hogs normally consume about half the corn produced in Minnesota. This year they can't do it--there is more corn and fewer hogs. The spring pig crop of Minnesota in 1948 was 3.9 million pigs; in 1947 it was 4.2 million; the 10-year average (1937-46) was 4.4 million.

On the corn side, Minnesota is producing a crop of 253 million bushels this year against a 10-year average (1937-46) of 201 million. Obviously, more than the usual quantity of corn will be available for other livestock for sale, or for carry-over.

The feeder who buys calves with the expectation of selling them in the fall of 1949 will be concerned with market prospects at that time. The swing of business conditions, up or down, is something no one can predict that far ahead. Buying to feed carries the most risk. But an indication of competing meat supplies can be given.

The 1948 spring pigs will reach the market in the winter and spring of 1949; the 1948 fall pigs will arrive during the summer. Neither of these will bring in as much total pork as the consumers would like to have. With large corn supplies, these hogs will likely be fed to heavy weights, which will increase the tonnage somewhat; but even so, the quantity of pork will not be excessive.

Good hog prices during the winter of 1948-49, coupled with large corn supplies, will invite an increase in numbers of sows to farrow in 1949. The early end of the 1949 pigs will start coming to market in October and November, but the heavy runs will not arrive until December and January. Thus fat cattle which go to market in November or early December of 1949 should not encounter too serious competition from hog supplies. Cattle which come in later can expect competition from hogs.

Beef cattle competition will come partly from corn-fed cattle, and partly from grass-fed cattle going direct to slaughter. Obviously, the weather conditions in the west will affect this supply. Dry weather would change the picture materially.

However, to get at this adequately, the number of cattle in the United States needs to be examined, and also the changes in the composition of the cattle herd. Total cattle numbers on January 1, 1948, were 78 million, as compared to 85 million in January of 1944 and January of 1945, and 76 million in Jan., 1942. These figures include both dairy and beef, but an analysis of beef cattle numbers indicate that the number of beef breeding cows has been sold down more closely than usual. In the summer of 1948 it was estimated that the beef cattle herd then contained a larger proportion of cows in relation to other cattle than at any time on record, and the smallest proportion of steers since 1940. Moreover, the proportion of the calf crop sold for slaughter in 1947 was the largest on record. The proportion of the calf crop carried into 1948 was the smallest since 1926.

This situation helps to explain why feeder cattle numbers may be limited for 1948-49 feeding operations. However, it also indicates that the reduced numbers of steers and young stock should limit somewhat the supplies of grass fat cattle that would arrive in the late summer of 1949.

SHEEP

Sheep numbers continue to decline in the United States. From an all-time high of 56 million on January 1, 1942, the numbers went down each year, to a total of 35 million on January 1, 1948. This low figure compares with an average of 39 million for the 10-year period 1916-25, which was the previous low period since 1900. From 1930 to 1940, numbers ranged from 50 to 53 million. But while United States sheep numbers have been declining, world sheep numbers have increased, especially in the past four years. The United States now has fewer sheep than it averaged during 1931-35; the world total is larger now than it was then.

The small number of United States sheep will, of course, mean small supplies of feeder lambs. As a matter of fact, it is estimated that the 1948 lamb crop is the smallest in the last 50 years. On top of that, it is indicated that some flock owners are holding back ewe lambs to rebuild their flocks; nine of the western states and two of the plains states carried over more ewe lambs in 1948 for breeding stock than they did in 1947.

HORSES

The horse and mule population is steadily getting smaller. In 1937 the United States had 15,748,000 horses and mules; in 1941, 15,184,000; in 1948, 9,150,000 head. Minnesota horse population is ½ what it was 10 years ago. Every horse that dies or is sold for fox feed means more feed for other classes of livestock.

Meat prices are high because:

I. Livestock numbers are low -

1. All cattle on farms January 1, 1948 - 78,564,000
   January 1, 1944 - 82,364,000
   January 1, 1938 - 65,249,000
   Cattle on feed 12 per cent below year ago.

2. Hog numbers on farms January 1, 1948 lowest since 1941.

3. Pig crop in 1948 smallest since 1941.

4. Sheep numbers at all-time low.

Red meat will be scarce in 1949. There will be 5 to 10 pounds less per capita - 142 pounds in 1949, 145 in 1948, 156 in 1947. Employment is at all-time high--61.6 million.

In the livestock field there may not be as much demand for mixed feeds as in the past several years. During the war and the few years following there was a tremendous demand for mixed feeds.

Because of the demand and scarcity of the rich protein feeds many mixed feeds contained a lower protein content than careful feeders will want now. With the abundant supply of home grown grains farmers will demand a well-prepared protein and mineral supplement.

OPPORTUNITIES AND PROBLEMS OF THE FEED INDUSTRY

L. H. Patten
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The predominant problem of the feed industry has always been, and will continue to be for some time, the promotion of scientific feeding in one form or another.

It amazes one to find a large percentage of feeders, even in highly developed farming communities such as southern Minnesota, who follow no recommended method, who pay little heed to what their agricultural colleges advise, who care not what the feed men recommend. This condition prevails to some extent in every agricultural community and represents our biggest problem and field for development.

Our problem, then, does not rest upon the idea of taking business away from our competitors, but in introducing a feeding program to the feeder who has been so backward that he is not in the least interested in anything progressive. Sometimes one thinks that funerals are the only solution, but we keep pecking away.

John D. Rockefeller began work at 16; at 25 he was in the oil business for himself; and at 55 he retired, the wealthiest man in the world. Shortly after his retirement, while playing golf on his Cleveland estate with W. T. Holliday, President of Standard Oil Company, John D. said, "In the matter of compensation one must recognize that there are two classes of people, the 'caretakers' and the 'builders'. The 'caretakers' are the backbone of an organization and their happiness and feeling of security are essential to a really efficient organization. We live in a competitive world, and it is, therefore, impossible to pay them more than the competitive rate. In addition to that, one must try to give them a feeling of security through continuity of employment, sick leave, old age pension and things of that sort."

"But," he continued, "there are also the 'builders', and they are relatively few. But they are the lifeblood of an organization, and you can never overpay a 'builder'."

Some of America's greatest business philosophy has been attributed to Andrew J. Carnegie, who said, "I never do anything that I can hire someone else to do better."

I list here ten responsibilities which every feed mill manager must either do himself or hire someone else to do better. Among this list we find an opportunity for every man to be a "builder" at least part of the time.

Duties of a Feed Mill Manager

(1) Office Manager
(2) Personnel Agent
(3) Research Analyst
(4) Production Manager
(5) Product Control
(6) Credit Manager
(7) Sales Manager
(8) Advertising Manager
(9) Traffic Manager
(10) Finance Director

Honestly now, do you believe there is a man alive who could fill all ten positions at one time with efficiency equal to the specialist in each of the ten catagories? Yet there are many men in the industry, especially among the smaller sized mills, who must attempt the above and many who do an admirable job. In the larger mills there are many executives who would be able to take any one of these ten catagories and become a specialist in each and who, as a part of their work, must be thoroughly familiar with all ten catagories.

I would select number 3 from this list, "Research Analyst", as the one field where a man can be a "builder" in the feed industry. Knowing how to interpret all the valuable information turned out by our universities and experimental farms, knowing how to screen the important from the unimportant and then make the practical application in the nature of improvement to already existing formulas in order that the feeder may benefit by a lower cost per unit of food produced.

To me, this is the way to be a "builder" in the feed business. There will be no Rockefellers or Carnegies in the feed industry just a long process of evolution, minor and major developments, generally involving the work of many people and not one individual.

Over one hundred years ago Karl Marx spent thirty years figuring out how 1200 million people should spend their lives for the next two thousand years. Yes, his wife and children starved to death in the process. Marx doomed free enterprise to certain failure because of the certainty of competition, which he said results in longer hours, less pay, poor and poorer working conditions and living standards until ultimately the whole system breaks down.

Karl Marx, who never did a day's work in his miserable life, could not possibly foresee how competition really works in a democracy to provide better products at lower prices and thereby a better standard of living for all classes of people.

Competition in the feed industry, if based upon the viewpoint that premiums with every sack, rebates and commissions to dealers, special discounts, etc., if we accept these as meaning competition, you can be certain that Karl Marx was right and competition will destroy the feed industry. If, however, competition is taken to mean the utilization of our facilities for improvement and composition of more efficient feeds based upon research and development resulting in a lower feeding cost per unit of food produced, then the feed industry and free enterprise will defeat all of the arguments of Marxism, Leninism, and Stalinism.

If an individual is anxious to follow the procedure of applying nutritional research, he should subdivide his program into the following seven details, each of which I will explain.

(1) Fundamental Research

a. Ingredients
b. Formulas
c. Feeding Efficiency

(2) Application of Research

a. Familiarity with new developments
b. Screening
c. Adaption of proven improvements
d. Mechanics of application

(3) Purchasing and Costs

(4) Mechanical Processing

(5) Packaging - Handling

(6) Sales and Sales Promotion

a. Advertising
b. Public Relations

(7) Product Distribution

Any feed man who sits down to think the thing out will decide that our "problem" is to develop the untouched resources present on farms not now operated according to recommended methods.

He will decide also that our "opportunities" are before us every day. The utilization and application of proven improvements in scientific feeding need special attention. All the other duties we perform in running a feed business will take care of themselves--these need special attention.

RECENT DEVELOPMENTS IN SWINE NUTRITION

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"Recent" is a comparative term. What might be recent or new to some individuals is frequently an old story to others. In discussing some of the newer or more recent developments in swine nutrition, I think it well to briefly review the present status of our knowledge--to find out where we stand in our information on the subject and then discuss the more recent findings in this field, possibly letting our thinking run into the future.

It has been definitely established that swine, like other animals, have certain fundamental requirements for protein of the right kind and amount, minerals, energy producing substances and certain vitamins if they are to grow and reproduce efficiently and economically. It is also known that the protein needs of young pigs are greater than for older or heavier hogs and that the needs for protein are greater during gestation and lactation. Work in general has shown that the following percentages of protein are needed for different stages of swine production in dry lot:

Bred sows	14 - 15
Lactating sows	15 - 16
Weaning up to 75 pounds	18 - 20
75 to 125 pounds	17 - 18
125 to 200 pounds	14 - 15
Over 200 pounds	12 - 13

For swine that have access to good pasture, the protein content in the dry feed can be 2 - 3 percent lower and obtain satisfactory results.

When it comes to minerals, it has been established that swine must have adequate supplementary amounts of calcium, phosphorus, salt, and other minerals, including some of the trace or minor elements, like iron and iodine, if nutritional deficiencies are to be avoided.

In the vitamin field, it is known that swine need fat soluble vitamins A, D, and E and the water-soluble vitamins (B-complex), thiamin, riboflavin, pantothenic acid, pyridoxine, niacin, biotin, folic acid, para amino benzoic acid, inositol, the animal protein factor, choline, and possibly other unidentified factors, in order to grow and reproduce. This practically covers the entire category of vitamins. From a practical standpoint, special attention needs to be given to vitamins A and D, especially when swine are confined; riboflavin, pantothenic acid, niacin, the animal protein factor, and possibly choline. The other vitamins are, as far as we know at present, supplied in adequate amounts under usual feeding conditions. When pasture enters into the feeding program the foregoing vitamins are supplied.

Recent research at various agricultural experiment stations indicates that the nutrition of swine can be divided into critical and non-critical periods. Reference to critical and non-critical does not mean that some of the nutrients can be overlooked and forgotten; but rather that the needs for certain nutrients, particularly vitamins, are more exacting during certain periods or stages in the life of the pig than in others.

The critical periods are:

(1) Gestation and lactation, especially in case of dry lot or when the dams do not have access to good forage or pasture.

(2) Young pigs up to about 75 pounds in weight, particularly in case of dry lot.

The non-critical periods are:

(1) Growing and fattening pigs from 75 pounds to market, especially if they had good feed up to that stage.

(2) Swine of all ages on good pasture.

The basis for this division into critical and non-critical periods is nothing especially new, because it has been known and realized in an indirect way for some time. However, it took some rather recent experiments, particularly those at the Wisconsin, Illinois, and Iowa Stations to point out these differences in a real way and set our thinking straight. For example, it was observed that sows and gilts fed rations normally considered adequate, in dry lot, were nutritionally inadequate for gestation and lactation. In the Illinois work, only 13 percent of the pigs were weaned in one trial and 7 percent in another on such rations. The additions of 10 - 12 percent good alfalfa meal during gestation increased the percentage of pigs weaned to 82 and 83 percent, even though the basal ration was fed during lactation. This demonstrates that proper feeding during pregnancy is very important in producing satisfactory results during lactation. The addition of 6 or 12 percent dried distillers solubles or the combination of solubles and alfalfa meal caused a five-fold increase in the number of pigs weaned. These experiments also showed that rye pasture and condensed fish solubles contributed factors which made for successful gestation and lactation.

Experiments with young pigs up to 75 pounds have shown that rations which are adequate after this period may prove to be more or less failures for this critical period. Here again, alfalfa meal, distillers solubles, condensed fish solubles, and certain B complex vitamin additions proved beneficial.

Experiments have also shown clearly that the feed of the dam during gestation and lactation or the type of feed the pigs have access to prior to weaning are factors in the performance of pigs after weaning. Adequate nutrition during gestation and lactation will produce pigs with a "nutritional bank account." Likewise, pigs adequately and properly fed up to 75 pounds in weight will have "nutritional reserves" which can be drawn upon later if necessary.

The support for the previous statement that the period from about 75 pounds to market weight in dry lot is not a critical period is found in the fact that rations which gave poor results in dry lot when fed to pigs up to 75 pounds were quite satisfactory for pigs weighing more than 75 pounds. This fact, however, should not encourage the use of inferior ingredients or carelessness in the formulation of rations to be fed during this period.

Consideration of the water-soluble and fat-soluble vitamins in the concentrates or supplements fed on pasture is not necessary. There are many experiments which support the statement that when pigs are on green pasture they are receiving such nutrients from the pasture and that the supplement to be fed with grain need not be considered in the critical group. The chief needs of swine fed grain on pasture are for supplemental minerals and protein. There is also evidence that the need for animal proteins are less when pigs are on pasture than in dry lot.

Now let us look at some of the information on which my statements were made. (Slides)

(1) Percent protein in swine feeds.
(2) Supplements to plant rations on gestation and lactation.

(3) Pure vitamins vs. natural sources in reproduction.
(4) Riboflavin in swine nutrition.
(5) Response of pigs to additions of B vitamins.
(6) Niacin in pig nutrition.
(7) Critical and non-critical periods.

Practical Considerations

What does all this mean in practical feed lot language? It means first of all that swine have specific needs for vitamins, the same as they have specific needs for energy, protein, and minerals. The vitamin needs, like the other nutrient needs, must be met through proper feeding if we are to get top performance and efficiency in swine production. The critical periods, when most attention should be placed on feeding, is during the early life of the pig. Start thinking about vitamins, especially B-vitamins for the young pig at the time the sow is bred. Continue to feed the young pigs well by feeding the sow well through the nursing period. Keep the vitamin supply high until the pig reaches 75 pounds in weight.

Make maximum use of pasture, good alfalfa meal, and/or other good supplements, like dried distillers solubles, milk products, condensed fish solubles, fermentation solubles or products which are good sources of the B-complex vitamins.

Remember that 80 percent of the cost of producing pork is feed. Good feed, good care, and proper disease control means efficient pork production. Efficient pork production means more profit and more pork on the table.

RELATION OF NUTRITION TO HATCHABILITY AND EARLY CHICK GROWTH

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Proper nutrition or feeding has been shown to be an all-important factor in poultry production. The more information we accumulate on poultry nutrition, the more we are impressed with the fact that the nutritive requirements for good hatchability are greater and more exacting than for egg production, and that good nutrition of the breeding flock is a factor in the performance of the chicks hatched from such a flock, especially during the early stages of growth. In other words, good egg production is no guarantee that the eggs will hatch well and produce good vigorous chicks.

Hatchability depends upon the "nutritional status" of the eggs which are being incubated or upon the presence in the egg of those essential nutritive factors that are required for the proper growth of the embryo. If any of the essential factors are absent or lacking in the egg at the time it is laid, the embryo will die prematurely, just as the hatched chick will die if not all the essential nutrients are supplied.

Good hatchability, as a rule, is not a problem when the breeders are out-of-doors and have access to green grass and sunshine. However, when the birds are confined indoors and deprived of green feed and direct sunshine, a large percentage of the eggs frequently fail to hatch unless green feed and sunshine substitutes are included in their ration. Feeding for hatchability and good early chick performance, in the main, is a recognition of the importance or essential nature of certain vitamins, minerals, and protein supplements in the ration.

Experimental work has shown that an insufficient intake of vitamin A may adversely affect hatchability and particularly the vigor and vitality of the chicks hatched. Although the effects of a vitamin A deficiency on hatchability are not so marked as those of some other vitamins, it, nevertheless, is a factor that must be reckoned with. Breeder rations should contain not less than 3300 units of vitamin A per pound of total feed to insure good hatchability and to produce chicks with proper vitamin A reserves.

Vitamin D, or the sunshine factor, is of singular importance in hatchability. Experimental work, without exception, has shown that when layers do not have access to direct sunshine or the amount of sunshine is inadequate, hatchability will be lowered unless vitamin D in some form is supplied. Many reliable and effective chick tested vitamin D products are available which, when used at the rate of 450 A.O.A.C. chick units per pound of total feed, will supply adequate amounts of this vitamin. It is well to remember that the vitamin D needs for optimum hatchability are somewhat higher than for egg production and several times greater than for growth.

Vitamin E, frequently referred to as the antisterility vitamin, has been shown to be required by poultry. Experimental work within the past several years has revealed that the addition of wheat germ oil as a source of vitamin E to a good ration containing ground whole grains, cereal by-products, alfalfa meal, protein supplements, minerals, and other essential vitamins, did not increase the total number of eggs. From this work as well as other observations, it appears that a ration containing good quality whole or ground grains, cereal by-products, alfalfa meal, protein supplements, essential minerals and other vitamins will supply adequate amounts of vitamin E to meet the needs for good fertility and hatchability.

Experience taught us that the feeding of milk products and green feed to breeders improved the hatchability of the eggs and the quality of the chicks that hatched. In other words, there appeared to be "something" in milk products and green feed which was favorable to the production of eggs that hatched well and chicks with vigor and vitality. Science in the past decade has shown that part of the "something" in the milk products and green feed which proved beneficial was riboflavin. The effects of riboflavin on hatchability are rather dramatic in that the hatchability of eggs can be increased or decreased by 75 percent in the course of two or three weeks. For example, birds on a ration deficient in riboflavin may produce eggs very few of which will hatch and the addition of adequate amounts of natural or synthetic riboflavin may increase the hatchability to 80 percent in the course of two or three weeks. The needs for riboflavin are greater for good hatchability than for egg production. A level of 1.3 milligrams of riboflavin per pound of total feed should prove adequate for good hatchability and a good quality chick; whereas, around 0.9 milligrams per pound of total feed is required to be adequate for egg production.

In recent years it has also been shown that other factors of the vitamin B complex in addition to riboflavin are involved in hatchability. Amongst these factors are pantothenic acid, folic acid, biotin and pyridoxine (vitamin B_6). From the available information on the distribution of these factors in feedstuffs and their requirement by poultry, it is my judgment that the average poultry ration made from the more common feedstuffs will not be found deficient in these two vitamins.

Another factor concerned in hatchability is a substance (or substances) present in certain animal products. The nature of this substance is not known. Nevertheless, it is apparent from the reports of several investigators as well as our own experience that animal products such as dried milk, meat scraps, fish meal, liver meal, etc., contain a substance (or substances) which is partially lacking in a presumably complete all-plant ration in which soybean meal serves as the chief source of supplemental protein. For example, in an experiment at our institution involving duplicate pens of birds, only 70 percent of the fertile eggs produced on the soybean oil meal ration hatched in comparison to 88 and 89 percent hatchability when the soybean oil meal was replaced either by an equivalent amount of meat scraps or menhaden fish meal protein. The inclusion of 5 percent of dried skimmilk in the meat scraps or fish meal ration did not improve hatchability; whereas, in case of the soybean oil meal ration, the milk accounted for a 14 percent increase in hatchability. Further work has shown that the inclusion of 5 percent meat scraps or fish meal in an all-mash soybean oil meal ration containing fermentation solubles as a source of riboflavin and other vitamin B complex factors was more effective than an equal amount of dried skimmilk in maintaining good hatchability. The use of more than 5 percent meat scraps or fish meal in the soybean oil meal ration did not show any further increase in hatchability.

It has been long recognized that the minerals, calcium, and phosphorus are important in egg production and in hatchability. A good breeder ration or a sound feeding program should make certain that these two mineral elements are not lacking. During the past few years it has also been shown that a deficiency of manganese in the ration will affect hatchability adversely and make the chicks more susceptible to perosis. Although the common poultry feedstuffs contain some manganese, it is good insurance to include some effective manganese mineral in the breeder mash.

Science and practical experience has established that proper nutrition of the breeding flock is reflected in the performance of the chicks during the early stages of growth as well as in hatchability. Chicks hatched from eggs which contain only enough of the vitamins to meet the needs of the growing embryo up to the time of hatching will not carry a vitamin reserve and must depend entirely upon

the adequacy of the man-made ration supplied them. On the other hand, if the breeders are fed so that they can produce eggs which are rich in vitamins, then the chicks hatched from such eggs will carry a "vitamin reserve account" on which they can draw if necessary. Inasmuch as the chick cannot add any nutrients to the egg from which it is hatched, it is obvious that it is the responsibility of the feeder to make certain that the breeders are supplied with all the necessary nutritive essentials so that they can produce eggs which contain all the nutrients essential for good hatchability and the production of "reserve account" chicks.

FEEDING THYROPROTEIN TO DAIRY CATTLE TO INCREASE MILK PRODUCTION

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It has been known since about 1915 that the thyroid gland has considerable control over milk production. In 1934 a worker in England found that milk production in cows was markedly reduced upon removal of the thyroid gland. In some experimental work carried out at the Minnesota station, it was found that the removal of the thyroid gland caused a 75-percent drop in milk production. The feeding of desiccated thyroid tissue to cows after the thyroid gland had been removed caused milk production to return to a normal level. Likewise, it was found that injecting the synthetic hormone, thyroxine, under the skin of similarly treated cows would cause milk production to return to a normal level. The scientists in England carried out one other very significant experiment. They found that the feeding of desiccated thyroid tissue to a normal milking cow would stimulate milk and fat production. Likewise, the injection of thyroxine caused a similar stimulation on milk and fat production. These experimental results have since been confirmed by work carried out at several experiment stations in this country.

From the practical standpoint the feeding of desiccated thyroid tissue is not economical because of the excessive cost. Furthermore, even if the total supply of thyroid tissue were made available for feeding cows, there would be enough for only a few cows. However, science during the past 10 years has taken a hand in overcoming this hurdle.

German scientists in 1938 found that under certain chemical conditions iodine could be added to proteins to produce material that possessed activity similar to dried thyroid tissue. Further work showed that the actual hormone, thyroxine, was produced by the process. In continuation of this study scientists of the dairy department of the University of Missouri found that iodine could be added to skim milk or casein, the protein contained in milk, under certain specified conditions with a similar result.

This material can be produced more cheaply and is even more active than dried thyroid. It does not lose potency on storage. The product, in various popular and scientific articles, has been called iodinated casein, iodinated protein, thyro-casein, thyro-lactin, thyro-protein and by the trade name "Protamone." In this discussion it will be referred to as thyroprotein. The sale of thyroprotein to dairymen is now permitted by the Food and Drug Administration.

The Missouri workers tested this new preparation on cows in their herd. When they fed 50 to 100 grams of thyroprotein to each of nine cows for three days, increases of 6.09 to 22.6 percent with an average increase of 8.59 percent in milk production were obtained. Six of the nine cows made an average increase of 6.77 percent in fat test and a 13.9 percent increase in fat yield. Similar trials have been conducted at the West Virginia, New Jersey and Louisiana stations. In these latter trials, amounts ranging from 10 to 15 grams daily were fed. These amounts produced increases up to 20 percent in milk production but as little as five percent increase was noted in some cows. At the same time the percent fat and the total amount of fat was increased. Increases of 0.32 to 0.98 percent in fat percentage and increases of 25 to 50 percent in total fat yield were observed. The most extensive work with thyroprotein has been carried out in England. Some of the results obtained by these workers are summarized in table 1.

Table 1

Results from feeding throprotein to dairy cows (from English data)

Number of animals	Amount fed (daily)	Increase in milk yield	Increase in heart rate
	Grams	Percent	Percent
3	15	16.7	9.3
23	20	21.9	-
12	30	32.7	25.8

A review of the data collected thus far indicates that on the average and within narrow limits the percentage increase in milk production is proportional to the quantity of thyroprotein fed. This relationship is shown in Table 1. Because of limitations in the animal itself, naturally this relationship would not hold where much larger amounts of thyroprotein than shown in Table 1 are fed for an extended period of time. As a matter of fact the feeding of excessive amounts of thyroprotein will cause a decrease in milk production. Therefore, for optimum results, careful control of the amount of thyroprotein fed to cows must be maintained.

The response of cows to thyroprotein feeding in terms of milk and fat production appears to vary from cow to cow and in most cases these variations cannot be explained at the present time. However, various workers have noted that no response is evident if the material is fed to a fresh cow and none is noted until the start of the declining phase of lactation. Likewise, very little response is evident during the last month or two of lactation and as a matter of fact there may be some tendency for thyroprotein to cause the cow to dry up in the late stages of lactation. Therefore, for best results, the thyroprotein should be fed for only the middle five or six months of the lactation period.

The English workers suggest that in mid-lactation the percentage response increases as lactation declines while the greater the initial yield at the beginning of the feeding, the greater the response in pounds per day. Good producing cows will, in general, give greater increases in milk and fat than poor cows. A poor cow cannot be converted into a good producer merely by feeding thyroprotein since the response obtained is partly dependent on her inherent ability to produce.

While the feeding of thyroprotein causes a marked increase in milk and fat production, a condition of hyperthyroidism is produced in the cow which must be taken into consideration. Thus there is an increase in heart rate, respiration rate and body temperature and a loss in body weight. These effects are to be expected since by feeding the material, an extra supply of thyroxine is taken into the body which increases the rate of metabolism or rate at which the body of the cow utilizes her food nutrients. In other words, she is using up food nutrients and the nutrients which are stored in her tissues.

Data collected at Beltsville indicate that the heart rate of thyroprotein-fed cows is related to the level of feed intake. When the level of thyroprotein feeding is kept constant, the heart rate can be markedly accelerated by increasing the total feed intake 25 to 50 percent. If the high feed intake is reduced, the heart rate then decreases. Also after cows have been receiving thyroprotein for four to eight weeks and there has been a considerable loss in body weight and milk production has declined sharply, the heart rate will also decline.

The heart rate is governed by the amount of energy the body has available for use, whether from the body tissues or from feed or both.

Most of the experiments reported thus far where thyroprotein has been fed to dairy cattle have been of short duration. In 1945 the Bureau of Dairy Industry decided to initiate an experiment to study the effects of feeding thyroprotein for successive lactations on the health, reproduction, and milk production of dairy cattle.

Thyroprotein was fed in the grain ration to a group of 12 first-calf heifers, beginning 50 days postpartum and continuing till 90 days before they were due to calve again. The material was mixed into the grain ration and fed at the rate of 1.0 to 1.5 grams per 100 lbs. of body weight. Corn silage and a mixture of alfalfa and timothy hay were used as forage. The Morrison Standard was used as a guide in calculating T.D.N. requirements. Some of the cows are now in their 3rd and 4th lactations.

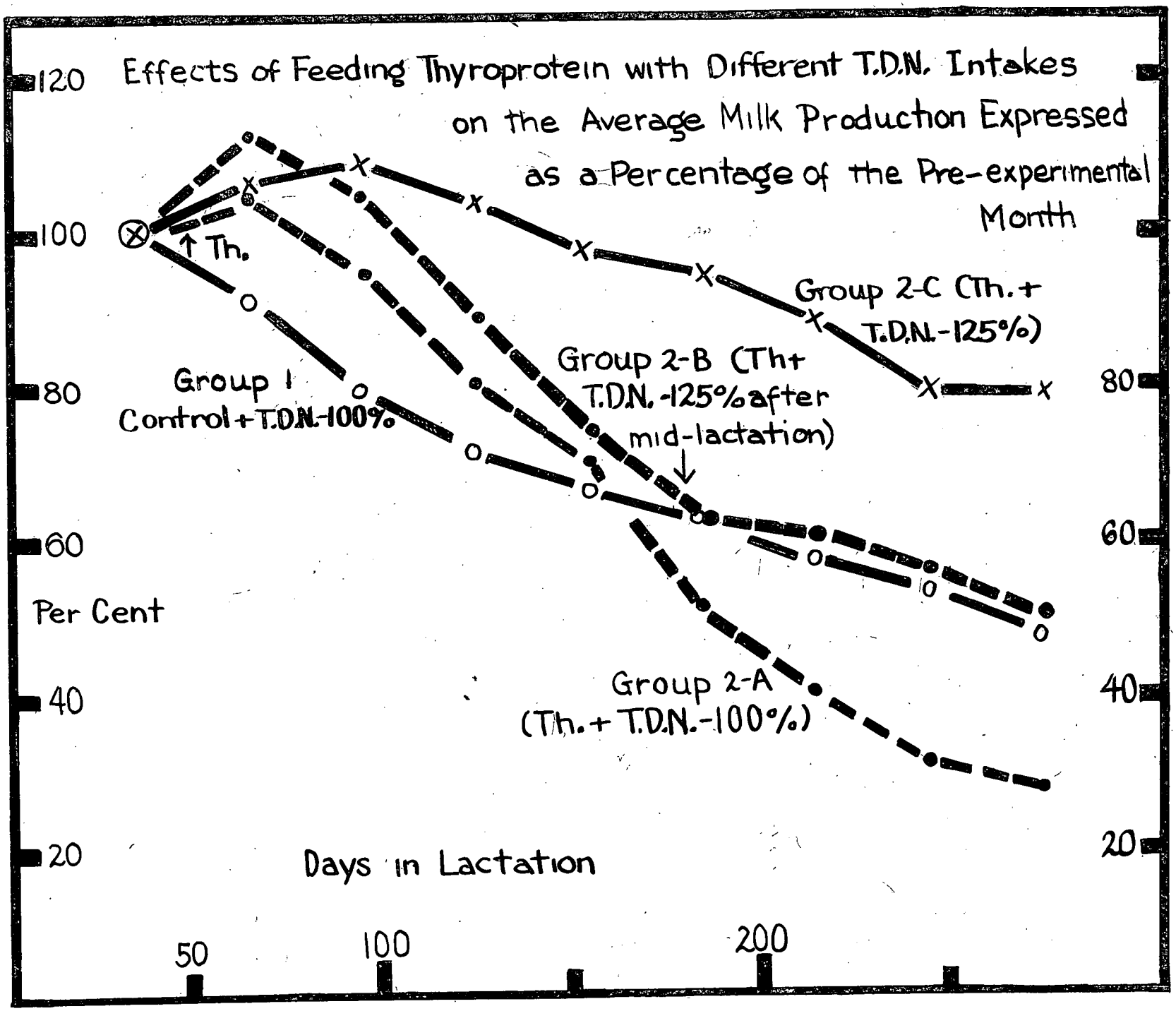
The results for the first lactation are shown in graph I. The milk production is expressed as a percentage of the milk being produced at 50 days postpartum. The cows in Group I (control) were fed T.D.N. according to the Morrison Standard and did not receive thyroprotein. The cows in Group 2A received thyroprotein and otherwise were treated the same as Group 1. It will be noted that thyroprotein feeding caused an increase in production above the control group for a period but the production later decreased to below the control group so that actual production was about the same in both groups. However, the cows in Group 2A lost heavily in body weight and some appeared somewhat emaciated. The increase in production apparently came from the body stores of fat, and body weight losses continued until production had decreased to about 10 lbs. per day, after which the cows were able to regain some of the lost weight.

Because of the extreme loss in body weight and the rapid decline in milk production after the initial stimulation in Group 2A, it was decided to increase the T.D.N. intake of Group 2B by 25 per cent at about the 170th day of lactation. It will be noted that the increased T.D.N. intake arrested the rapid decline in milk production. The rapid loss in body weight was stopped and as a matter of fact the cows gained in weight.

Because of the rapid decline in milk production after initial stimulation by thyroprotein in Groups 2A and 2B and the loss of body weight in Group 2B, and because it was demonstrated that these unfavorable effects could be arrested by an increase of 25 per cent in T.D.N. intake, it was decided to add the extra 25 per cent T.D.N. to Group 2C at the same time the thyroprotein was added to the ration at 50 days along in the lactation. It will be noted from Graph 1 that this procedure permitted a marked stimulation in milk production and a persistent lactation response in Group 2C. Body weight was also maintained.

The results obtained with the first lactation in this experiment demonstrated that in order to maintain body weight and milk production when feeding thyroprotein, it is necessary to feed about 25 per cent more T.D.N. for both maintenance and milk production than is required by the Morrison Standard. This procedure was then adopted for all cows receiving thyroprotein after the first lactation.

The production responses in the 2nd and 3rd lactations have been disappointing when compared to the 1st lactation. Some of the cows have not produced any more milk during these lactations than they produced in the first lactation even though all cows received 25 per cent extra T.D.N. beginning at the same time the thyroprotein was added to the ration. The reason for this performance is not clear. It is possible that the stimulation produced in the first lactation as a result of feeding thyroprotein may have depleted the cows of some nutrient or nutrients which they were not able to completely replenish during the dry period.


Effects of Feeding Thyroprotein with Different T.D.N. Intakes on the Average Milk Production Expressed as a Percentage of the Pre-experimental Month
120
100
80
60
40
20
Per Cent
Th.
Group 1
Control + T.D.N.-100%
Group 2-C (Th. + T.D.N.-125%)
Group 2-B (Th+ T.D.N.-125% after mid-lactation)
Group 2-A (Th. + T.D.N.-100%)
Days in Lactation
50
100
200

The feeding of thyroprotein has not thus far affected the health and reproduction of the cows, and all the calves have been normal at birth. The only abnormality noted was an increased number of services needed for conception for the Holstein cows. This observation on Holsteins is being checked further with more animals.

Obviously if more feed must be fed in order to maintain body weight and milk production, the question arises as to whether the extra milk produced will pay for the extra feed. With the data at hand at the present time, it is difficult to come to any definite conclusion on this point. According to Technical Bulletin No. 815 of the United States Department of Agriculture, a 20 per cent increase in feed intake by a normally fed cow not receiving thyroprotein will increase milk production about 13 per cent. If, by feeding thyroprotein, 20 per cent more milk could be produced and 20 per cent more feed, that would leave an increase of 7 per cent in milk production to pay for the thyroprotein and the extra trouble of feeding it. However, as previously stated, more complete data are needed on the relationships of feed intake to various levels of thyroprotein feeding, milk production, and body weight losses. Some further attention should also be given to the nature of the body weight losses.

The purebred breed associations have expressed concern over the use of thyroprotein in making official records. Rules prohibit such use because the record would not be a true expression of the inherited milk producing ability of the cow. However, unscrupulous individuals will undoubtedly try to improve the official records of their cows by feeding thyroprotein. This, of course, calls for methods for the detection of its use. Undoubtedly, scientific investigation will lead to the discovery of effective methods.

It seems doubtful that thyroprotein should ever be mixed into regular dairy grain mixtures since it should not be fed except during certain periods of the lactation and because of the variation in effects produced in individual cows. Where thyroprotein is being sold today, it is sold in pellet form mixed with the extra feed which the cow receives in addition to the regular grain mixture. The quantity of extra grain fed under these conditions is two pounds. It seems doubtful whether two pounds is sufficient extra feed where thyroprotein is being fed.

We do not recommend the feeding of thyroprotein by the average dairyman. The only place where it might be used safely and with the chances of some possible economic benefit, depending on the milk-feed price ratio, would be in commercial dairies on the East and West coast where the cows are disposed of after they have dropped to a low level of production.

DAIRY CATTLE NUTRITION RESEARCH AT BELTSVILLE

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The Division of Nutrition and Physiology is one of the four Research Divisions of the Bureau of Dairy Industry. The Division employs a staff of some fifteen professional people trained in various fields of the biological sciences. These scientists work together as a team for the purpose of solving problems involving the nutrition and physiology of dairy cattle. We have some fifty projects in progress, some of which are of a fundamental nature while others have direct practical application.

In the time allotted to me it is not possible to discuss but a few of the projects and I have chosen those which I feel might be of some practical significance to you. It should be kept in mind that the data presented are from projects still in progress, although the results obtained thus far justify the conclusions drawn.

Protein Requirements of Dairy Cows

Protein concentrates are generally the most expensive part of a grain mixture used in feeding dairy cattle. In general it is recommended that where the roughage part of the ration consists of a poor quality grass hay, the grain mixture should contain about twenty to twenty-four per cent of protein; where the roughage is mixed hay about sixteen to eighteen per cent, and where roughage is a good quality of legume hay, a twelve to fourteen per cent protein grain mixture is recommended.

In order to determine whether it is possible to recommend lower levels of protein, an experiment was set up in 1945. Three groups of cows were fed the following grain mixtures during lactation.

	Low	Medium	High
Yellow Corn Meal	55.5	36.0	23.0
Ground Wheat	10.0	25.0	27.0
Beet Pulp	25.0	20.0	20.0
Soy Bean Meal	4.5	15.0	26.0
Soy Bean Oil	2.0	1.0	1.0
Salt	1.0	1.0	1.0
Calcium Phosphate	2.0	2.0	2.0
Total Protein Content	10-11%	14.5-15.5%	18.5-19.5%

These mixtures contain essentially the same fat, fiber, calcium, phosphorous and T.D.N. content.

In order to keep the protein intake at a low level, the cows were fed Number 1 timothy hay at the rate of 10 to 12 pounds per 1,000 pounds body weight and only 3 to 4 pounds of Number 1 alfalfa per 1,000 pounds body weight. Corn silage was fed at the rate of 15 pounds per 1,000 pounds body weight. T. D. N. was fed at the rate of 110 per cent of Morrison's standard. None of the cows have received pasture while on this experiment.

The results of the first lactation and second lactation are shown in Table I.

Table I

Effect of Level of Protein Intake on Milk and Fat Production

Group	Milk	Fat	Fat	F.C.M.	Mature Equivalent F.C.M.
	lb.	%	lb.	lb.	lb.
			1st Lactation		
Low	7,627	4.39	334.9	8,975	8331
Medium	7,742	4.31	333.8	8,103	8480
High	6,617	4.73	312.9	7,341	8145

Group	Milk	Fat	Fat	F.C.M.	Mature Equivalent F.C.M.
	lb.	%	lb.	lb.	lb.
			2nd Lactation		
Low	7,672	4.27	327.9	7,983	8111
Medium	8,234	4.35	358.3	8,667	8667
High	7,088	4.61	326.9	7,892	8006

The averages for the three groups for the second lactation have maintained the same relation to each other as in the first lactation. It would thus appear that the cows in the low protein group produced about as well in the second lactation as in the first, indicating that the continued feeding of the low protein ration did not adversely affect production. Some of the cows are continuing for a third lactation.

It will be noted that the low protein grain ration contains only 4.5 per cent of soy bean meal whereas the high protein mixture contained 27.0 per cent. It should also be kept in mind that the low protein mixture was fed with a high proportion of timothy hay in the ration.

While final conclusions must await a final summary of all the data it appears probable that it will be possible to recommend a lower protein content by 3.0 to 4.0% for the grain ration of dairy cattle than is now recommended. In some instances this would mean that the dairyman would not have to buy any protein concentrate especially where legume forage is available.

Anemia in Dairy Calves

It has been observed that anemia as indicated by a low blood hemoglobin content occurs in calves in the herds at Beltsville. The anemia may be present at birth or it may develop any time up to 60 days of age. The anemia will usually disappear at about 80 to 90 days of age when the calves consume considerable hay.

It was found that a mineral mixture of copper, iron, manganese and cobalt was effective in curing the anemia. These minerals were then fed singly to determine which was effective in producing a cure. The calves were usually about 30 days old when the single mineral elements were added to the ration. The results of these additions are shown in Table 2.

It will be noted that iron was the only element which caused an increase in

hemoglobin between 30 and 60 days of age.

Table 2

Effect of Various Minerals on the Average Hemoglobin Value of Calves Blood

Age	6 calves Iron	4 calves Manganese	4 calves Copper	3 calves Cobalt
1-7	8.5	7.1	8.2	9.3
8-14	8.3	7.7	8.1	9.0
15-21	7.8	7.7	7.3	8.3
22-28	7.6	6.5	7.6	7.8
29-35	7.8	6.7	6.6	7.1
36-42	8.6	6.8	6.3	7.2
43-49	9.1	6.5	7.4	7.2
50-56	9.7	6.1	6.6	7.8
57-63	9.8	7.5	7.5	8.0
64-70	10.3	7.0	7.5	8.5
71-77	9.3	7.4	7.9	8.7
78-84	9.4	7.6	8.2	8.6
85-91	9.7	7.6	9.1	8.3

The growth of the calves was studied by grouping them according to the lowest hemoglobin values noted for two consecutive weeks. The average gains of the calves which had the normal values for hemoglobin were somewhat greater than for those that showed values that came between 5.0 and 7.9 and 8 and 8.9 grams of hemoglobin per 100 ml. of blood as showm in Table 3.

Table 3

Average Gain of Calves Falling Into Various Groups

		Grams hemoglobin per 100 ml. of blood		
		Between 5-7.9	Between 8-8.9	Above 9.0
		lb.	lb.	lb.
Jersey	(22)	85 (4)	93 (4)	88 (14)
Holstein	(55)	110 (10)	125 (28)	133 (17)
Danes	(13)	79 (3)	106 (21)	86 (8)
Cross Breed	(22)	95 (3)	96 (10)	97 (9)

Figures in parenthesis denote number of calves.

Thus it would appear that iron might be beneficial in calf mixtures where this type of anemia occurs. The extent of the anemia over the country is not known since this is the first report of such a study in calves of this age group where iron has been used as a supplement. It is contemplated that we will determine whether it is possible to prevent the anemia from developing in the calf by the addition of iron to the ration of the dam.

Effect of Feeding Whole Milk and Supplemental Vitamin A to Young Calves

The problem of the value of supplemental feeding of vitamin A to calves where a limited quantity of whole milk is fed from birth to about 3 months of age has been subject to considerable controversy during the past 5 years.

The period of growth from birth to 90 days of age is the most critical in the calf's life since most losses occur at this stage. As a result of current domestic feeding practice for calves of this age, the vitamin A intake has been considerably reduced compared to calves reared under natural conditions where an abundant supply of milk from the dan and whatever green grass the calf might desire is available. This decrease in vitamin A intake might have something to do with the high mortality in calves during this period, especially under winter feeding conditions.

In order to study the storage of vitamin A of calves reared under natural conditions, two pregnant cows were turned to pasture early in the spring about 3 weeks before calving. The two heifer calves which were dropped were permitted to run with their dams on pasture from birth to 90 days of age. Thus these two calves could obtain whatever quantity of summer whole milk they desired and in addition any green grass they would consume. In addition male calves, which received colostrum milk for 3 days and a limited quantity of whole milk to 60 days of age along with a grain mixture and U.S. No. 2 alfalfa hay, were placed on experiment. The whole milk fed was from cows receiving winter rations. One calf out of each pair of calves also received in addition various quantities of vitamin A in the form of cod-liver oil for varying periods of time.

At 90 days of age all calves were placed on a vitamin A deficient ration to determine how long it would take to deplete their stores of vitamin A. The calves were considered depleted when the blood plasma vitamin A decreased to a level of 4.0 micrograms of vitamin A or below per 100 milliliters of plasma.

The results are shown in Table 4.

Table 4. Effect of vitamin A intake on depletion time

Animal number	Treatment	Depletion
		Days
278	With dam on pasture to 90 days of age	120
329	" " " " " " " " "	113
708	50,000 I.U. to 98 days of age	125
513	" " 92 " "	106
517	" " 40 " "	98
2399	" " 35 " "	69
2707	" " 30 " "	53
515	" " 30 " "	45
512	No extra vitamin A	39
518	" " " "	32
518	" " " "	30
519	" " " "	26
2703	" " " "	24
520	" " " "	17
2700	" " " "	16
711	" " " "	13

It is interesting to note that the two calves which ran to pasture with their dams required up to 4 months for depletion whereas calves which received no supplemental vitamin A and were reared according to present day methods of limited whole milk feeding required less than 30 days in 75 per cent of the cases for the depletion period. Where 50,000 I.U. of vitamin A per day was fed for varying periods of time the depletion time was in proportion to the quantity of vitamin A fed.

The growth data on seven pairs of Jersey males up to 90 days of age were available for summarization. One calf of each pair received no supplemental vitamin A whereas the other animal of each pair received some supplemental vitamin A for varying periods of time. The calves which received no supplemental vitamin A did not make as good gains from birth to 90 days of age as the calves

which received supplemental vitamin A. We have lost 5 calves out of a total of 16 from various causes in the non-supplemented group and only 2 out of 11 calves in the supplemented group. There was also a greater incidence of scours in the non-supplemented group than in the supplemented group.

Blood samples were drawn each week for analysis of vitamin A and carotene. The values for the two calves which ran with their dams and the supplemented calves were considerably higher than the non-supplemented calves. As a matter of fact the values for the calves which received no supplement were in some cases exceptionally low.

These results show that calves that are reared under natural conditions, that is, permitted to run with the dams up to 3 months of age, will have a store of vitamin A which will last them about four times as long as it would if they were reared according to present day practices without supplementation. Feeding supplemental vitamin A increased the rate of growth of calves, as compared with the growth by those not fed a supplement, and it did increase the length of depletion time and did appear to increase the chances of rearing the calf. The depletion time appears to be a good measure of the reserve vitamin A available since the depletion time is proportional to the quantity of vitamin A the calves received during the period from birth to 90 days of age.

It would thus appear that some calves reared on winter rations have a very low reserve of vitamin A to draw on at 90 days of age even though the quality of hay fed up to this time was excellent. In order to insure some extra store of vitamin A some supplemental vitamin A should be fed. In the light of these results the effect of feeding as much as 50,000 I.U. per day to calves for the first 60 to 70 days should be studied further.

Experiments at several stations have shown that the feeding of 5000 I.U. per day for 30 days in capsules was not effective in controlling scours in calves. According to our calculations this would furnish only 3½ days reserve supply of vitamin A at 90 days of age according to the technique used in the present experiment. It is little wonder therefore that this amount of vitamin A showed no effect on the health of calves.

Comparative Efficiency of Different Methods of Conservation of Alfalfa

During the past 4 years the Bureau of Dairy Industry in cooperating with the Bureau of Plant Industry, Soils and Agricultural Engineering has been conducting a study of the comparative efficiency of different methods of handling an alfalfa crop. The crop has been harvested as wilted silage, barn dried hay with and without heat, and as field cured hay with and without the effects of rain during the field curing.

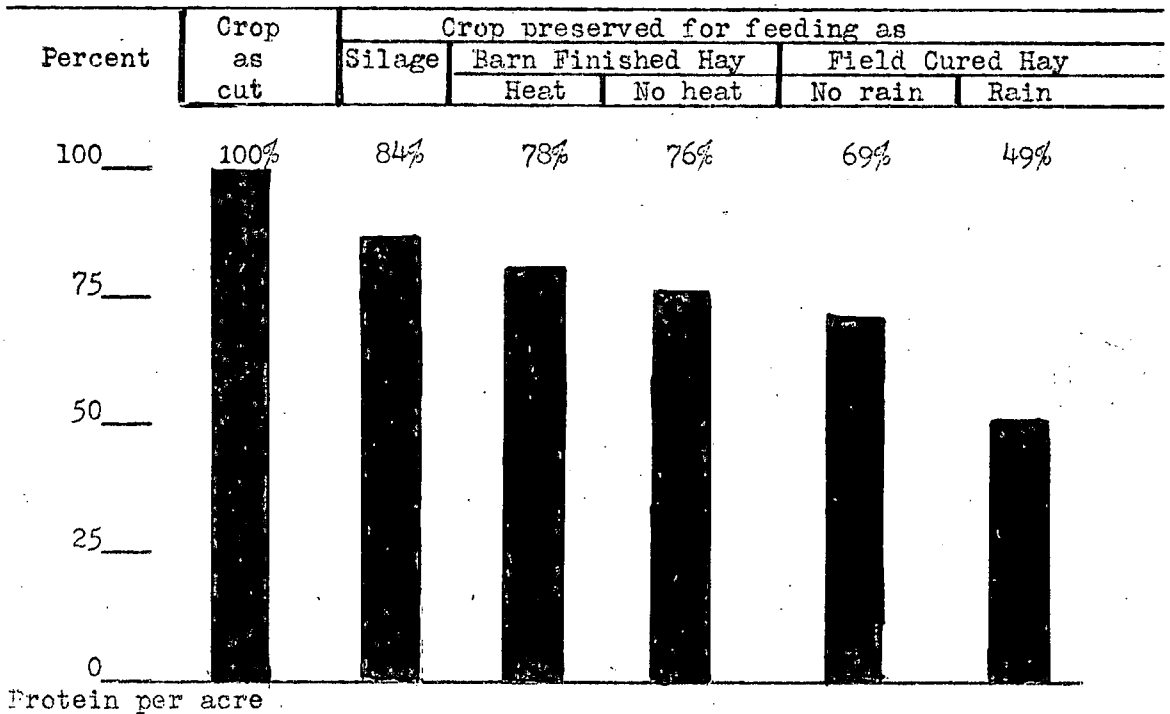
The effect of these different procedures on the protein conservation is shown in chart 1. It will be noted that there are great differences in the amount of protein conserved as affected by the different procedures. As a matter of fact a farmer will lose 164 pounds more protein per acre if the field-cured hay crop is damaged by rain than if the same crop is put up as silage. This difference in loss is equal to the protein in 5 bags of linseed meal.

These crops harvested by different procedures were fed to milking cows to get the effect on milk production. Taking into consideration the differences in milk production and the losses of nutrients associated with the different methods of conservation, a chart was made up giving the comparative amounts of milk produced per acre.

In one set of figures field-cured hay was used as a base of 100 with which to compare the other procedures and in the other case the field-cured hay which

CHART I

PROTEIN PRESERVATION IN 3-WAY FORAGE HARVEST
BELTSVILLE, MD. 1945-1947



	Crop as cut	Silage	Barn Finished Hay: Heat	Barn Finished Hay: No heat	Field Cured Hay: No rain	Field Cured Hay: Rain
Protein per acre Loss - Pounds		67	91	108	144	223
In dry matter as fed - %		20.72	18.68	18.70	18.19	17.19

was weather damaged because of rain, was used as a base of 100 for comparisons. The results are shown in chart 2.

It is quite apparent that by conserving the alfalfa crop either as grass silage or barn-cured hay, considerably more milk will be produced per acre than if the crop is put up as field-cured hay, especially if the hay is damaged by rain.

Comparative Antirachitic Value of Field-Cured Hay, Barn-Dried Hay and Wilted Grass Silage.

According to present opinion, hay crops contain little or no vitamin D before they are cut. It is only after the crop is cut and while it is exposed to the rays of the sun during the curing process that activation of certain plant sterals takes place to form vitamin D.

With the newer methods of conserving hay crops, such as curing hay in the barn or making wilted silage, the time of exposure to the rays of the sun is less than when the crop is cured in the field. Consequently, when barn-cured hay or wilted silage is the sole source of vitamin D for calves, it might be questionable whether they would obtain enough of the vitamin to meet requirements.

In the summer of 1945 and 1946 a second cutting of alfalfa was harvested simultaneously as field-cured hay, barn-cured hay, and wilted silage. These crops were fed to growing calves as the sole source of vitamin D for a period of 6 months. When the forages were fed at the rate of 1.2 to 1.7 lbs. of hay or hay equivalent of alfalfa silage, rickets did not develop and the calcium, phosphorus, and phosphatase content of the blood plasma remained within the normal range.

The vitamin D content of these forages harvested in both 1945 and 1946 was determined by means of the rat bio-assay technique. The results are shown in Table 5.

Table 5

Vitamin D Content of Alfalfa Harvested by Three Methods

	Wilted Silage	Barn-dried	Field-cured
	I.U. per lb. air-dry basis		
1945	254	213	440
1946	393	264	400
Approx. radiation exposure gm. - cal./cm.^{2}	230	530	1410

It is quite apparent that the wilted silage and barn-cured hay, contrary to popular opinion, did contain considerable vitamin D under Beltsville conditions.

Further studies were conducted to determine where the vitamin D was coming from in forage harvested with little exposure to the sun as in the case of wilted silage. Green alfalfa plants were cut and brought immediately into the laboratory. The absolutely green leaves were separated into one lot, the yellowish and half dried leaves into another and a third lot was separated which contained only the dried leaves and stems. Bio-assay of these separations were made and the results are shown in Table 6.

CHART II

RELATIVE MILK YIELDS PER ACRE FROM FORAGES 1/
3-WAY FORAGE HARVEST, BELTSVILLE, MD., 1945-1947

Percent of Field Cured Hay		
Damaged by rain	Cured without rain	
140	112	Wilted silage
145	116	Barn dried hay - heat used
135	108	Barn dried hay - no heat
125	100	Field cured hay - no rain
100	80	Field cured hay - rain damaged

1/ Based on dry matter preserved and dry matter consumed per 100 pounds 4% milk produced.

Table 6

Vitamin D Content of Three Portions of the Alfalfa Plant at Time of Cutting

	I.U. per pound air-dry material
Green leaves	33
Half-dead leaves	290
Dead leaves	2700

Apparently the vitamin D is present at time of cutting in the dried leaves and stems, which accounts for the vitamin D in wilted silage and barn dried hay.

From these data with calves and the rat bio-assays for the vitamin D content of alfalfa harvested as wilted silage or as barn-dried hay, under Beltsville conditions we should not expect rickets to develop in calves when this forage is fed in liberal quantities as the sole source of vitamin D. While it may be feasible to include some vitamin D in calf mixtures fed to 3 to 4 months of age during the period when hay consumtion is not great, we do not feel that such supplementation is necessary after 4 months of age where good management practices are carried out.

TRACE ELEMENTS IN POULTRY NUTRITION

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All feed manufacturers, at some time or other, are confronted with the problem of deciding what trace elements should be added to poultry mashes. Often there is considerable pressure from various mineral salesmen, a few of whom advocate adding all the minerals in the book to mashes including some which are actually unnecessary and costly. I wish to present to you a summary of existing information on trace elements in poultry nutrition. I hope that the information that I will give you will help to clear things up in your mind in regard to these nutrients.

Apparently your committee that chose this subject for discussion is somewhat psychic, for one of the most interesting findings over the past years in regard to poultry nutrition was since made with the trace mineral cobalt. I will say more about cobalt later.

In order to know just what we are talking about, I want to give you a little background information about minerals and discuss the meaning of a few terms. First, from a chemical point of view, when we speak of minerals we mean all the inorganic elements found in feedstuffs and any other materials, for that matter. The minerals of a ration are the part which is left, or the ash, after burning off the organic part of the ration, with a few exceptions.

Some of these minerals are required by animals and some are not. There are a total of 13 minerals known to be required by poultry today, as shown in Table I.

Table I
"Minerals" for Poultry
(Inorganic Elements)

"Minerals" Required	Trace "Minerals" Required	Trace "Minerals" NOT Required*
Calcium	Manganese	Flourine
Phosphorus	Iodine	Silicon
Potassim	Iron	Aluminum
Sodium	Copper	Boron
Chlorine	Zinc	Molybdenum
Magnesium	Cobalt (organic only)	Brimine
Sulfur (organic only)		Selenium
		Arsenic, etc.

* as far as known today

Several of these elements, such as chlorine and iodine, are not really minerals in the usual sense but are generally included in such lists. All of them are better called "inorganic elements".

I have listed in Table I, in the third column, several elements which are known to have an important place in the nutrition of certain plants or, in some cases, other animals but which are not essential to poultry as far as is known today. It is very possible that sometime in the future someone will find that one or more of these minerals are essential for chickens in very small amounts. At least, with the best techniques available today no one has been able to prove that the chicen requires them for normal growth. I should say, however, that no one has yet devised a diet to study these elements which is completely free of all traces of them.

Recent experimental work with certain organic arsenic compounds at the U. S. Department of Agriculture has shown such compounds to be effective in promoting growth of chicks on rations high in soybean oil meal and low in the so-called cow manure factor. Inorganic arsenic is not effective. The growth response is not specific for these arsenic compounds, however,

Trace Elements

The trace elements are those elements which are present in very small amounts in our usual feed stuffs. The designation of what is a trace element (or trace mineral) is an arbitrary one from the standpoint of nutrition. I presume we can say that any element that is needed in the ration in amounts lower than about 0.01% (0.2 lb. per ton) should be considered a trace element. As many as 30 to 40 or more trace elements are naturally present in our grains and concentrates which go to make up our mashes today. Only a few of these are essential in nutrition. These include, for poultry, the elements manganese, iodine, iron, copper, zinc, and as was discovered recently, cobalt, although cobalt can only be utilized in the organic form as far as is known now. There is no evidence today that any other trace element is needed by the chicken, or by any other forms of livestock, for that matter.

Each trace element is as important to the chicken as any other ingredient in the ration. Each one has certain functions to perform and is necessary for life itself. In other words, if we could devise a ration that did not contain any one of these trace elements, the chicken fed such a diet would eventually die. The following table (Table II) shows the important functions of each of the trace elements which we are considering today.

Table II
Function of Trace Elements
for Poultry

Trace Element	Function
Manganese	Prevention or perosis, for hatachability, and egg shell strength, (phosphatase enzyme)
Iodine	Thyroxine formation
Iron	Hemoglobin molecule, oxidizing enzymes
Copper	Hemoglobin production, enzymes
Zinc	Carbonic anhydrase enzyme
Cobalt (organic only)	Vitamin B_{12} (nucleotide formation?)

Most all the trace elements are known to combine with other compounds in organic combinations within the tissues of the body and perform their function in the organic form. However, in the case of cobalt, apparently the tissues of the chicken are not able to build the vitamin B_{12} molecule which must be fed as the complete molecule in the ration.

A few words about this new vitamin B_{12} are in order here. Vitamin B_{12} was recently isolated by chemists at the Merck Laboratories, New Jersey, where they made use of a test procedure developed at the Poultry Department, University of Maryland. Vitamin B_{12} is extremely active in pernicious anemia and in certain other types of anemia in humans. Very recently it has been found that this vitamin has animal protein factor activity for chickens and it appears that it will have extreme practical importance in poultry rations but it is not available commercially as yet. It is known that this vitamin contains approximately 4 per cent of cobalt in its molecule. Thus an important relationship between a vitamin and a trace mineral has been established. This probably explains why cobalt is effective, under certain conditions, when fed to cattle and sheep. We are at present studying this relationship here at the Poultry Divisiom and we hope that by next year we will have considerabl more information on this problem to give to you.

Practical Recommendations

Now, what you folks want to know is what trace elements must be added to poultry rations during their manufacture. There are many conflicting statements seen and heard about the need for trace minerals. I could point out several recent instances of misleading advertisements from some of our larger mineral companies, although it is only fair to say that most mineral companies are attempting to do an honest job with the limited information available. I will present a summary of the existing information so that you can decide for yourself what minerals are necessary in your own case. Practical recommendations are given in Table III, column 3.

Table III
Trace Elements for Poultry

Trace Element	Amount Needed per ton of feed	Amount to add per ton of feed
Manganese	1 to 2 ounces	4-8 ounces (Manganese sulfate)
Iodine	1 gram*	1 gram (in iodized salt)
Iron	18 grams	None
Copper	1.8 grams	None
Zinc	Not known	None
Cobalt	Only used in organic form (Vit. B_{12})	None

* 454 grams per pound

These figures are taken largely from figures presented by the Sub-Committee on Poultry Nutrition of the National Research Council. The important point in examining this table is to distinguish the difference between what must be present in the ration (column 2) and what must be added to a ration (column 3). Most trace elements are present in adequate amount in the feedstuffs used to make poultry rations and, hence, the addition of such minerals to poultry rations is a wasteful and costly procedure.

There are only two trace elements which should be added to our poultry rations. These are manganese, which should be added as manganese sulfate or manganese dioxide at a level of $\frac{1}{4}$ to $\frac{1}{2}$ pound per ton of mash, and iodine, which may be added in the salt or in certain premixes. Incidentally, the usual iodized salt on the market today apparently contains enough iodine to prevent any appearance of goiter, although the level it adds to a ration is less than the level recommended by the National Research Council. If you wish to buy a special mixture containing these minerals already mixed together at a cost which justifies its use, there is certainly no harm in that. It shouldn't cost over a few cents per ton to add these two minerals, however.

Until a research laboratory can offer good experimental proof that iron, copper, zinc, or cobalt, or any trace element, other than manganese or iodine, should be added to a practical diet to improve growth or to prevent the appearance of any deficiency symptoms, it is my recommendation that you do not waste your money on mineral mixtures that are higher priced because of the addition of any of these minerals. I do not condemn, however, the use of minerals such as bonemeal or limestone products which happen to have any of these trace minerals as impurities, as long as you do not have to pay extra to incorporate them in your ration. In fact, as our soils become more and more depleted of trace minerals in our country today and as our feedstuffs raised on such soils contain less and less of these trace minerals, the presence of minerals such as cobalt, iron and copper in rations is certainly not going to hurt anything and may turn out to be good insurance as long as the cost isn't over a few cents per ton. There is certainly need for further research along these lines.

Before closing, I want to give you just a few results of some work which we are doing in the Poultry Department here which gives evidence that existing ideas on minerals in poultry rations are perhaps going to change to some extent in the future.

Table IV
Preliminary Mineral Studies with Chicks
(Battery Fed)

Supplement to Starter Mash	Number Chicks	Weight at 4 weeks grams
None	20	253
5% black soil	20	274
10% black soil	20	289
5% sand	20	298
10% sand	20	301

In Table IV you will see the results of some growth experiments with young White Leghorn chicks raised in batteries and fed practical rations. To some of these chicks we fed two different levels of ordinary black soil and to others two different levels of ordinary river sand. Both the soil and the sand gave us somewhat better growth than without them. These results have been confirmed in other experiments which we have run. We do not obtain this difference when the birds are fed on the bare ground. We are at present trying to find out the reason for this increased growth. It may be merely a matter of grit because when we add various levels of grit to this same practical ration similar growth increases are noted. Not all samples of grit have given us the same results, however, and we are beginning to think that a trace mineral may be involved. We hope to find the answer soon, since it directly concerns all of us and all poultry raisers in this state and elsewhere. We have not gone far enough in our work to make any practical recommendations as yet, however.

In conclusion, the only trace elements which we know must be added to our poultry rations today are manganese and iodine. Until the time comes when proof of the need of any of the other minerals is established in carefully conducted experiments there is no reason why feed manufacturers or farmers should pay extra for them. When such proof can be given for any other trace mineral, we at the Poultry Department will be among the first to recommend its use. In the meantime, there is no harm if these other trace minerals are present in mineral concentrates as long as the cost of the concentrate is not increased because of their presence and as long as the product is not sold on a false and misleading basis.

FEEDS, FEED SUPPLEMENTS, AND MEDICATED FEEDS FOR LIVESTOCK UNDER THE FEDERAL FOOD, DRUG, AND COSMETIC ACT

Henry E. Moskey
Federal Security Agency
Food and Drug Administration

The Federal Food, Drug, and Cosmetic Act defines the term "food" as articles used for food or drink for man or other animals, and the term "drug", in part, as articles intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals. Therefore, interstate shipments of feeds and drugs for animals including poultry are subject to the provisions of the Act.

Most states have laws to regulate the sale of feeds for livestock and poultry within their borders. The Food and Drug Administration in the enforcement of the Federal Food, Drug, and Cosmetic Act actively cooperates with the various state feed officials in their efforts to prevent the sale of adulterated or misbranded feeds entering their states. A food is adulterated under the Act if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it is otherwise unfit for food.

Salvaging water-soaked grain which has become decomposed, putrid and moldy by feeding it to animals has long been a problem from the standpoint of enforcement of the Act. Agents or brokers interested in salvaging such grain insist that decomposed, putrid and moldy grain is safe and suitable for animal feeding, especially for poultry and swine. The Food and Drug Administration has consistently taken the stand that moldy feed is not safe and suitable for animal feeding and under the law is an adulterated article which cannot be permitted for purposes of food for man or other animals. One agent brought an injunction suit against the Administration in an attempt to force it to release a large import shipment of decomposed, putrid and moldy wheat for poultry feeding. After hearing considerable testimony on both sides of the question the Federal court refused to grant the injunction. It may interest this group to know that the most impressive testimony presented by the Government was that of poultry raisers. One testified that he had a great deal of money invested in broilers and could not, under any circumstances, jeapardize his investment by feeding spoiled and moldy grain in his batteries.

Information of a questionable nature dealing with the relation of vitamin E to reproduction had led many livestock raisers to believe that wheat germ oil, a source of vitamin E, has value in correcting breeding difficulties and sterility of livestock. There is now ample scientific evidence that vitamin E has no relation to reproduction in livestock. We have little doubt that the vitamin may be an essential nutritional requirement. However, it is our understanding that most feeds for livestock furnish an ample supply of this vitamin for nutritional purposes. Those manufacturers who wish to perpetuate the sale of wheat germ oil now claim that wheat germ oil may contain factors other than vitamin E which play an important part in the prevention and treatment of breeding difficulties, sterility and abortion. One manufacturer of wheat germ oil is even claiming that his product will prevent and cure Bang's disease of cattle. Unfortunately, some of our livestock breeders and practicing veterinarians have been impressed with the theories advanced by the manufacturer which he claims are based on scientific evidence.

As far as we have been able to determine, this so-called scientific evidence consists largely of statements from satisfied users and others who do not have a thorough knowledge of the numerous causal factors and pathological conditions associated with failure to conceive and abortions in the female and sterility in both males and females. The Food and Drug Administration has seized several large shipments of wheat germ oil under labeling which the Government alleged bore false and misleading claims. At present we are preparing to take criminal action against a certain manufacturer who apparently desires to have the whole issue settled by a trial before the Federal court.

Our records show that the business of manufacturing and selling mineral feed supplements for poultry and livestock has grown to amazing proportions. Many of you recall when products of this character were represented, principally through means of collateral literature, for the prevention and cure of various disease conditions of animals and, in part, for creating a resistance against infectious or contagious abortion of cattle. The Administration has been active for a long time in removing misbranded products of this character from interstate channels. Recently, there has been a trend on the part of manufacturers of mineral feed supplements to discontinue representing such products for therapeutic purposes. Nevertheless, many of these mixtures or formulas on the market are irrational in their composition and contain drugs and other substances which have no nutritional value.

The principal argument advanced for retaining Epsom salt or Glauber's salt in the formulas is that their presence prevents the constipating effect of the mineral elements. An animal nutritionist with whom we discussed this matter informed us that he is of the opinion that mineral feed supplements are too constipating unless a laxative ingredient is incorporated. Sodium bicarbonate is another ingredient frequently found in mineral mixtures for supplementing the feeds. We have pointed out to manufacturers that sodium bicarbonate has no food value and serves no useful purpose in mineral feed mixtures.

One section of the Federal Food, Drug and Cosmetic Act deems a food to be adulterated if it bears or contains any added poisonous or deleterious substance which is not required in the production of the food or which cannot be avoided by good manufacturing practice. In preparation for a criminal prosecution case which we anticipated would be contested in court, a number of controlled tests were conducted with a product composed chiefly of mineral oil with smaller amounts of fish oils and other substances represented as a treatment for coccidiosis of chickens and blackhead of turkeys. The preparation when added to the growing mash as directed on the label furnished five per cent mineral oil. Harmful results were noted in all test groups fed with mash containing the concoction. This confirmed other studies which established that mineral oil interferes with the assimilation of certain fat soluble nutritional elements particularly vitamin A. While mineral oil in low percentage is used in manufacturing mineral feed supplements to allay dust and to prevent caking, the small amount used for this purpose, according to animal nutritionists, is not likely to interfere with proper digestion and assimilation of essential nutritional elements.

The Administration recognizes the fact that the most practical way to administer drugs to a large group of animals or fowls is to mix them thoroughly in feed. Many interested manufacturers of live-

stock and poultry feeds have now placed on the market feed mixtures containing active drug ingredients. Such mixtures come under the definition of a drug and must comply with the drug provisions of the Act. The feed ingredients, under the circumstances, must be regarded only as the vehicle or carrying agent for the drug and may be declared as such in compliance with state feed laws.

Many of the newer drugs added to feeds would bring such products under the statutory definition of a new drug. A new drug cannot be marketed legally in interstate channels until a new-drug application with respect to it becomes effective as provided by the Act. One section of the Act provides for the promulgation of regulations for exempting from the operations of the new-drug section, new drugs intended solely for investigational use by experts, qualified by scientific training and experience to investigate the safety of drugs. In the event that a drug has already been extensively used under practical conditions for a considerable period of time and there is no longer any question as to its safety when so used, it may no longer be a new drug as defined by the Act. Extensive publicity has been given in various popular magazines and newspapers to the experimental work with iodinated casein having thyroid-like properties for feeding to poultry and dairy cows. New-drug applications have been permitted to become effective for the use of an iodinated casein to be fed to poultry and dairy cows solely on the grounds of its safety. The applications which are effective were accompanied by convincing scientific evidence that treated birds were safe for human consumption and that the milk from treated cows was safe for children. Recently a new-drug application became effective for a complete feed for dairy cattle containing iodinated casein as an active drug ingredient. With respect to the proper labeling of the feed the Administration has taken the stand that it is a drug intended for a drug purpose and that it must be labeled to comply with all the drug provisions of the Act including, of course, adequate directions for its use and adequate warnings against its misuse. While we have permitted a few new-drug applications to become effective for 15-milligram pellets of diethylstilbestrol to be implanted under the neck skin of cockerels for tenderizing purposes, no new-drug applications have become effective for synthetic estrogens to be administered in the feed for such purposes, because there is not sufficient evidence to show that the birds treated in this manner are safe for human consumption.

Recently our attention was called to the investigations of the Food and Drug Division of the National Health and Welfare Institute at Ottawa, Canada, on the feeding of synthetic estrogens to poultry, in which it was shown that synthetic estrogens fed to poultry for a sufficient length of time to produce a tenderizing effect had a tendency to accumulate in the fatty tissues and the liver to such an extent that the birds proved harmful for human consumption.

The interest shown by some manufacturers in thiouracil for fattening poultry and livestock has presented a serious problem in connection with new-drug applications. Thiouracil has high toxic potentialities for man; we must be convinced beyond any doubt that the edible portions of the treated animals are safe for human consumption before we can consider permitting such new-drug applications to become effective. Chronic toxicity studies on animals extend over a considerable period of time, are quite expensive and perhaps for this reason are not as yet available for thiouracil. Chemical methods to detect minute quantities of the

chemical substance in the tissues and glands of treated animals, should they be developed, would be of considerable help in determining some of the factors involved. Histological studies of treated animals are also essential to determine what changes, if any, have been produced by feeding the chemical. According to our understanding, experiments have shown that thiouracil can be administered to hogs to produce a fattening effect by inhibiting the thyroid activity. The pancreas of hogs is used almost entirely for the manufacture of insulin. We do not know what effect the chemical would have on the pancras of hogs from the standpoint of producing insulin and its safety to man. Biochemists associated with chemical manufacturers tell us that in their opinion thiouracil is rapidly eliminated from the body fluids. To produce a fattening effect the chemical must be used for a sufficient length of time to slow up thyroid activity and a satisfactory answer to the over-all problem has not been forthcoming. This is also a serious problem from the standpoint of the enforcement of the Federal Meat Inspection Act; the enforcing officials of that Act do not look with favor on feeding any toxic substances to animals which are to be slaughtered for human consumption.

TRENDS IN FUNDAMENTAL NUTRITION RESEARCH

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Most of the members of this audience are feed manufacturers, feed dealers, or are associated in their business with the feed trade. Hence, you are interested primarily, and quite rightly so, in things which can be put into a bag and which can be sold to the livestock producer. But like all good businessmen, you would like to know as much as possible about the commodity which you handle, about the use it is put to, and about the things it can and cannot do and the reasons therefore. It is in this field where your interest meets directly with those of the scientist working in animal husbandry, of the nutritionist and of the biochemist. The feed industry as represented by the Northwest Feed Manufacturer's Association for instance, gives practical recognition to this fusion of interest by providing financial support for fundamental studies in nutrition. This is only one reason why it is a pleasant assignment to talk to this group about "Trends in Fundamental Nutrition Research."

Most of the problems with which the science of nutrition is dealing fall essentially into one of three major fields of research, as shown in Table I.

Major Fields of Fundamental Nutrition Research

1. Nutritional Requirements of Various Species
   (a) Qualitative
   (b) Quantitative

2. Supply of required nutrients
   (Content in natural foods; stability, digestibility, proteinquality, etc.)

3. Function of each substance in chemistry of the living organism.

Until we understand the nutritional requirements of our domestic animals under all conditions which they encounter in their life cycle including disease, our methods of feeding are largely empirical. Today, I do not know of any single species whose nutritional requirements are completely known and defined. At some future time when we will understand these nutritional requirements, we may find that some of our present feeding practices are perfectly valid, that some of them may not lead to optimum nutrition but that they will be largely retained because we depend now, and will continue to depend on the products of our soil as the ultimate source of feed. Other feeding practices or certain feeds may be considerably modified as more knowledge accumulates. I can conceive of a ration which can be compounded from not quite pure substances which might promote faster growth in pigs, for instance, than any ration now used in practice. Yet such a ration might not be economical or practical to use for the farmer and it might not be desirable from the standpoint of national economy. Knowing the makeup of such a ration, however, we can perhaps attempt to duplicate it with natural feeds properly supplemented.

Slide 2 shows the ingredients of a ration on which small laboratory animals such as mice, and rats, can be brought through a whole life cycle and this can be repeated for several generations. Whether or not such a ration would support the survival of a species indefinitely is, of course, not known at the present time. Similar rations have been used quite successfully to raise pigs and calves from birth to the age of several weeks or months. Somewhat modified rations of similar general make-up have been used for chickens. Although this is certainly a good start towards a complete understanding of the nutritional requirement of these few species, we still do not know if we could replace, for instance, the

natural fat which is added to these rations by a highly purified synthetic fat, nor do we know (and this is even more important from a practical standpoint) whether or not the animal protein, casein, could be successfully replaced in these purified rations by a purified plant protein or a mixture of plant proteins. These problems are at the present time receiving much attention in various laboratories and considerable progress should be made within the next few years.

Components of a Purified Rations
for Laboratory Animals

1. Major Organic Ingredients:
   - Protein (usually casein)
   - Fat
   - Carbohydrate (usually sugar)

2. Mineral Salts: (Usually containing 12 or more mineral elements)

3. Minor Organic Ingredients:

Vitamin A	Pantothenic Acid
Vitamin D	Niacin
Vitamin E	Choline
Vitamin K	Para-amino benzoic acid
Thiamine	Inositol
Riboflavin	Folic Acid
Pyridoxine	Biotin

Ascorbic Acid (?)

One of the outstanding features of recent nutrition research has been the use of different species of living organisms for the study of the fundamental nutritional requirements. These species range from various bacteria through insects, fish, birds, to different mammals, such as the dog, the fox, the mink, the monkey, the pig, and the calf. Actually only a beginning has been made in what may be termed comparative nutrition, but the studies which have been made so far have yielded extremely valuable results. With bacteria, for instance, it has been found that some of them can grow on diets of sugar and a few inorganic salts. These organisms, therefore, can build up themselves and all of the components which they contain from the sugar and the few salts fed to them. Other bacteria, particularly some of the lactic acid bacteria, which grow so well in milk have much more complex nutritional requirements and these requirements are in many respects quite similar to those of some of our domestic animals.

Several important findings have emerged from the study of the nutritional requirements of bacteria and I am going to touch upon only a few.

1. The growth of some bacteria, as for instance, lactobacillus casei, is quite proportional to the amount of certain vitamins which are available to them on the medium on which they grow. Thus, it is possible to measure, for instance, the content of riboflavin or of niacin, or of pantothenic acid in foods, or feeds, by the growth response which this organism produces when growing in a suitable extract of the feed. The same general relationship holds true for the growth response produced by some micro-organisms, when certain amino acids, the components of proteins, are present in the medium in different amounts. Through the use of micro-organisms as suitable tools in analytical procedures, we are now better able to assess and to describe the nutritional value of our feeds in definite terms.

2. Another interesting development which grew out of the study of the nutritional requirements of micro-organisms has been the isolation of what is

referred to as vitamin B_{12}. A bacterium, lactobacillus lactis, was found to require for its growth an unknown substance present in liver and in other animal products. When these products were fractionated, a pure substance was finally obtained which in extremely minute quantities produced a great growth response for lactobacillus lactis. This same substance, referred to as vitamin B_{12}, has also been found to produce a marked growth stimulation in chickens when they were fed on rations containing protein from plant sources only, such as soy bean oil meal and corn. Of additional great interest is the fact that this substance, Vitamin B_{12}, has been reported to be effective in the treatment of cases of human pernicious anemia. As was the case with the amino acid, methionine, twenty-five years ago, vitamin B_{12} is an example of the isolation of a dietary essential for higher animals through the use of micro-organisms. We know very little about vitamin B_{12} at the present time. It has been reported to contain the trace element, cobalt, and this makes one wonder if there is any connection between the relatively high cobalt requirement of ruminants like the cow and the sheep and the formation of vitamin B_{12} by micro-organisms in the rumen of these species.

3. There is another connection between micro-organisms and the nutrition of domestic animals which might be mentioned briefly. The alimentary tract of all species contains, except during the first short period after birth or hatching, large numbers of micro-organisms. Some of these micro-organisms produce substances which are important for the animals in whose alimentary canal the micro-organisms live. It has long been known for instance, that micro-organisms which live in the rumen of a cow can synthesize some of the B vitamins like thiamine and riboflavin and hence, under ordinary conditions of feeding, the cow does not depend solely on its feed for these vitamins. The calf, on the other hand, before its rumen is functional, requires a full dietary supplement of these vitamins. It is not known how many vitamins are produced by micro-organisms in the alimentary canal. Some of them may not yet be recognized. We do know, however, that if the micro-organisms in the alimentary tract are inhibited by such measures as feeding of sulfathalidine, sulfasuxidine, in sufficiently high levels, an acute deficiency of folic acid can be produced in some species. Associated with this deficiency is an inability of the blood forming organs of the animal to make a sufficient number of red and white blood cells. This condition can be corrected by feeding of either folic acid or of substances which contain this compound. Therefore, it is quite possible that the nutritional value of a feed depends not only on what the animal can digest and absorb from that feed, but also on the effect it has on the micro-organisms in the intestinal tract of the animal.

4. Experiments which are being carried out particularly at Notre Dame University, on the raising of germ-free animals are, therefore, of great interest and they certainly have more than academic value as might appear on first glance. Such experiments, however, are very difficult to perform and are extremely expensive.

When I mentioned purified rations earlier, I raised the question on whether the purified plant protein could replace the purified animal protein in the synthetic rations used for small laboratory animals. This is very important from a practical standpoint because protein concentrates from plant sources such as soy bean oil meal, linseed meal, cottonseed meal and peanut meal, are so extensively used in livestock feeding. These feeds are used primarily as protein supplements in rations containing mainly cereal grains and fibrous feeds. In recent years, considerable evidence has been accumulated that corn-soy bean rations, when fed to swine in dry lot or cereal grain-soy bean rations when fed to chickens, do not support optimum nutrition unless they contain additional supplements. Growth performance on such rations has been sub-optimal and, particularly with swine and chickens, reproduction has been unsatisfactory. Thus, for instance,

the hatchability of eggs produced on such rations has been found to be only about 40% or even less. In looking for supplements which would improve these rations, it has been found that materials derived from animal sources gave the best response. The milk proteins, meat proteins and particularly such materials as fish meals and condensed fish solubles, improve corn-soy meal rations. One group of research workers has found that cow manure is a rich source of such supplementary nutrients. We do not know at the present time what the chemical nature of these substances is, perhaps they are vitamin B_{12}, perhaps something else.

Another very important development in nutrition research has been the recognition that there is an inter-relationship between various nutrients and that this inter-relationship can directly affect the growth performance of the animal. This is another problem of great practical importance to the livestock industry and also to the feed industry. It has long been known that the main protein of corn is deficient in two amino acids called tryptophan and lysine and the poor performance of swine for instance on rations containing only corn has been ascribed primarily to an insufficient supply of these amino acids. If a corn ration is supplemented with a feed like tankage, the nutrition of the animal is very much improved as you well know. Tankage does not supply much more tryptophan than is contained in the corn proteins, although it is rich in lysine. Tankage, however, is a rich source of niacin and a conclusion was drawn therefore that it was primarily a niacin deficiency which was responsible for the poor growth of animals on the unsupplemented corn rations. During the last few years, it has been found that one of the functions of tryptophan in the animal is to serve as a potential source of niacin because on a ration containing a liberal allowance of tryptophan, the niacin requirement of the animal is greatly decreased. The supplementary effect of natural feeds added to corn rations may, therefore, consist in supplying both additional quantities of lysine and tryptophan as well as niacin. Furthermore, it has been observed that unless the animal receives a sufficient intake of vitamin B_6 or thiamine or riboflavin, its ability to use tryptophan is greatly reduced. It is becoming increasingly evident, therefore, that a rather delicate balance exists in which the various nutrients must be furnished to the animal in order to achieve optimum nutrition and efficiency of feed utilization. Fortunately, most of our natural feeds and particularly mixtures of natural feeds, appear to contain the different nutrients in such amounts that this balance is fairy well attained. Otherwise, we would not have had the success in the field of livestock production that has been accomplished with natural feeds.

The few points which I have raised above are simply illustrations of some of the trends in modern nutrition research. They may serve to emphasize as well how much more knowledge remains to be accumulated by fundamental research and they may suggest how this knowledge may be translated into practical operating procedure for the animal industry.

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