MINNESOTA FEED SERVICE

University of Minnesota Agricultural Extension Service, St. Paul September 1961

FULL-FAT SOYBEAN MEAL IN POULTRY FEEDS

PAUL WAIBEL

Soybean meal has been an excellent protein supplement for poultry rations. Now we have the possibility of improving this supplement even more by leaving the oil, formerly extracted, in the meal. This new product is called full-fat soybean meal.

Before discussing the use of full-fat soybeans, two important points should be emphasized.

First, soybean meal, formerly called soybean oil meal, is a by-product of soybean oil manufacture. Since soybeans contain about 18 percent oil and this oil was of considerable value, it paid to extract the oil and sell the remaining meal to agriculture as a protein supplement. By older methods of oil extraction there was about 5 percent of oil left in the meal. By the modern solvent extraction methods, only ½ percent of oil is left in soybean meal. This is the product that we have been using.

Second, simple stomached animals do not utilize native soybean protein well. A heat treatment is required during the processing to get the full nutritional value of soybean protein.

Now we can leave the oil in the soybeans. Thus the product is identical to the whole soybean, with the exception that proper processing and heat treatment are required to render the full nutritional value of the bean to the animal. The product contains about 37 percent protein and 18 percent fat. Thus we call the product full-fat soybean meal.

There are both advantages and disadvantages of using of soybean protein supplement containing 18 percent of fat.

Let's consider an important advantage first. The inclusion of more fat in the diet by using whole soybeans results in higher energy feeds. Furthermore, growing chickens and turkeys and, in some cases, mature birds perform at a higher rate with improved efficiency of feed utilization when fed diets of higher energy content.

There is only one possible disadvantage in the use of full-fat soybeans. This is the effect of having such a high amount of an unsaturated fat in the diet and its relationship with the production of a softer carcass fat in the product. When whole soybeans are included in the diet, the carcass fat tends to become more unsaturated or softer. Now this may be a disadvantage from the carcass acceptability point of view. However, human nutritionists are attempting to increase the amounts of unsaturated fatty acids in human diets so here we may have a compensating advantage.

While much research needs to be done in this area, to determine the amount and manner that full-fat soybeans can be used, it appears that the presence of the fat in the bean will be of considerable help in the improvement of nutrition for poultry. Naturally the question would arise, "What would happen if a farmer took local soybeans, ground them, and used the product in the ration?"

For young animals, there would be a severe growth depression. This is because the young animal cannot completely utilize the amino acids present in the protein of the raw meal. Some research indicates that older animals can use the raw soybeans somewhat better, provided they are given increased levels to help overcome the deficiencies.

Just what is the nature of this raw soybean defect? Why is proper processing and heat treatment necessary to produce a nutritional product?

There are various theories on the difficulties with raw soybeans. One commonly held theory is that raw soybeans contain a trypsin inhibitor. This is a substance which inhibits enzyme action and therefore digestion in the intestinal tract. There is disagreement regarding the nature of the trypsin inhibitor.

Irvin Liener, professor of biochemistry at the University of Minnesota, cites the fact that soybeans contain a toxic protein and that heating is required to destroy this protein. An interesting occurrence is that the feeding of raw soybeans produces a greatly enlarged pancreas.

Another theory states that with such a hyper-active pancreas, the excess pancreatic secretions are wasteful to the overall economy of the animal, and therefore, inefficiency results.

Other workers believe that amino acids from raw soybeans are not available because they are locked in a structure which the animal cannot release and that heating unlocks this structure so that the amino acids become available.

In any case, processing is needed to produce a nutritional meal. First, indications are that the beans must first be made into flakes. These flakes are very thin and result in improved digestibility of the oil.

Second, the meal must be heated properly. One method of doing this is to heat soybean flakes for 30 minutes at 107° C. If ground soybeans are merely heated, not all of the energy of the soybeans will be released. A recent finding at Cornell University is that the flaking step may be omitted if the final ration is pelleted.

Even though good results have been obtained under experimental conditions, we do not yet have sufficient information to indicate the practical methods required to produce such top quality meals. There is, however, much interest in this area and the high tempo of research which is going on at the present time should allow us before too long to make some very definite recommendations regarding the feasibility of using full-fat soybean meal for poultry rations.

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Feed Cost—Not Rumen Development Important in Calf Feeding

R. G. WARNER

It's better to base a calf feeding program on the quality and cost of the feed available and on the rate of gain you want than on how the feed will affect a calf's ruman development. Although one of the oldest calf feeding recommendations has been to encourage roughage consumption in order to develop rumen capacity and produce calves which will consume large amounts of forage, there's little data to indicate that it ever turns out that way.

Although dry feed consumption of either hay or grain is the most important stimulus for initiating rumen development, studies by the author at Cornell University indicate there's little reason to believe the amount of hay a calf eats has much to do with his eventual rumen capacity.

There's no good reason to discriminate against grain in a calf feeding ration on the grounds it may hinder rumen structure development.

Present data indicate that the quality of available forage, the relative cost of milk, milk replacer, grain, or hay, and the rate of gain a feeder desires are more important in a calf feeding program than the need to develop a rumen.

What brings about changes in the rumen? What effect does feeding have on these changes? Should feeding be tailored to these changes?

This article reviews the experimental work we carried on at Cornell University and reported at the University of Minnesota Animal Nutrition Short Course. Major feeding implications are reviewed in the box to the right.

Now to background the situation.

There are three structural characteristics of the rumen which change dramatically during calfhood. They are:

1. The mucosal layer or inner lining which is made up of many fingerlike papillae or openings through which nutrients pass into the blood stream.

2. The muscle layer of the wall which is responsible for the holding and mixing of feed.

3. The volume or capacity.

We observed each of these characteristics closely, in the studies reported here.

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Diets and Papillae Development

We designed initial experiments to examine the differences which could be found by feeding young dairy calves widely different diets such as hay, grain, or milk. Young calves were housed on raised platforms so they wouldn't eat their bedding. They were fed a basal milk diet and were weaned early onto a diet of either hay alone or grain alone. Others were continued solely on the mineralized milk diet.

At slaughter, the most striking difference in the rumens was the degree of papillary development. The milk calves had rudimentary papillae while those fed either hay or grain were well developed.

The extensive development of papillae of grain-fed calves cast serious doubt on our preconceived notion that roughage was required for rumen development since the grain mixture contained less than 7 percent crude fiber.

We designed a subsequent experiment to examine the relative effect of different materials on papillae growth. We compared an inert bulky material, such as plastic sponges or nylon bristles, with chemical materials such as are found in the rumen fermentation. An example of the latter is a mixture of the volatile fatty acids.

We introduced these materials directly into the rumen through a rumen fistula of 5-week-old calves and continued for about 7 weeks. At slaughter, those receiving the inert bulk had only rudimentary papillae while those on the fatty acid treatments had well developed papillae. Calves on milk only but eating copiously of shavings (an almost nonfermentable roughage) also had rudimentary papillae. **These studies showed that growth of papillae was the result of chemical stimulus rather than any physical action by coarse feed.**

Subsequent experiments demonstrated that butyrate and propionate were far more stimulatory than acetate. Other work bears this out. It appears, therefore, that the acids which are metabolized to the greatest degree by the rumen wall itself result in the most pronounced growth of papillae.

Are the papillae permanent structures? A chance observation led us to test the hypothesis that the papillae were not permanent but would disappear if the source of fatty acids were removed. Calves were fed on hay and grain to an age of 16 weeks.

A few were slaughtered and, as expected, papillae development was extensive.

Other calves were put on platforms and the hay and grain replaced with milk. After an additional 20 weeks, the calves were slaughtered and the papillae were observed to be small, rudimentary, and no larger than those of milk fed calves. The papillae had thus retrogressed in the absence of active rumen fermentation.

It was clear from these studies that the papillae are dynamic structures and that a continual supply of fatty acids and/or other fermentation products are necessary to keep them intact.

There is no question that papillae are important structures to the young ruminant. Recent studies have shown that the rate of absorption of volatile fatty acids by calves with well developed papillae exceeds that of calves raised on milk only and having only rudimentary papillae.

Rumen Capacity

Perhaps one of the oldest calf feeding recommendations has been to encourage roughage consumption to develop rumen capacity. Theoretically this technique should produce calves that will eat large amounts of forage. There is very little actual data, however, to support this suggestion other than the obvious one of economics.

We measured the reticulo-rumen volumes of over 80 head of cattle to study this question.

It is clear that during the early weeks those calves fed grain or hay developed more capacity than those on milk and that this difference continued. By 40 weeks the hay group exceeded the others markedly.

Of interest, however, is the capacity of five mature cows averaging about 1,200 pounds. Their rumens were about 33 to 43 gallons in volume which is considered to be normal. However, they contained only 30.3 liters per 100 kilograms of ingesta-free weight. This is about the same proportion as for milk and grain calves 40 weeks old. It is about one-half the hay-fed calves.

These data were surprising in that both milk-fed calves, allowed to nibble sawdust bedding, and grain-fed calves had rumens as large relative to their body size as normal mature cows.

The critical question is whether the advantage is size, apparent for the hay fed calves, would last until maturity. Since these latter animals did not grow as rapidly on hay alone as the others they were always smaller. In all cases they were potbellied. It is our inter-

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BARLEY—IT'S USE IN SWINE RATIONS

R. J. MEADE

Barley, properly supplemented, is an excellent feed for growing-finishing swine. When pelleted it may be nearly equal to No. 2 yellow corn in feeding value.

In this article we consider some of the research in barley feeding and some of its advantages and disadvantages.

Some Deficiencies

Barley generally has the same nutrient deficiencies characteristic of all cereal grains. It is slightly deficient in total protein, in quality of protein, calcium, phosphorus, riboflavin, pantothenic acid, vitamin B_{12}, vitamin D, and in vitamin A potency for growing-finishing swine. Although it contains sizeable quantities of niacin, this vitamin may not be available to the pig.

It is quite high in tryptophan, but contains slightly less sulfur amino acids —methionine and cystine—and lysine than required by weanling pigs.

Barley vs. Corn

Barley, because of its higher crude fiber content, is lower in total digestible nutrients than yellow corn. Thus its use as the sole cereal grain in a ration otherwise adequate may result in slightly slower and perhaps less efficient gains than when corn is used as the sole cereal grain.

Lester Hanson and E. F. Ferrin of the University of Minnesota in 1954 obtained results of this nature. Pigs fed all-barley rations ate more feed daily yet gained more slowly and less efficiently than did pigs fed the rations based on corn.

The thin barley used in their studies contained 5.4 percent crude fiber, while the plump barley contained 4.1 percent crude fiber. This small increase in crude fiber content hardly seems enough to cause the 9 percent decrease in daily gain and 4 percent increase in feed requirement over that of pigs fed the plump barley rations.

The pigs fed the thin barley rations gained 12 percent more slowly and required nearly 14 percent more feed than the pigs fed the corn rations. Apparently pigs fed the thin barley having a lower test weight, containing more hull, and having more crude fiber than either the virgin or plump barley were unable to consume enough T.D.N. daily to promote more rapid and efficient gains.

Pelleted Barley

North Dakota Studies—W. E. Dinusson and his colleagues at North Dakota State College in 1953 first reported on pelleted rations where barley was the sole cereal grain. Their ration was composed of 81 percent ground barley, 8 percent soybean meal, 5 percent meat scraps, 5 percent alfalfa meal, and minerals. They realized considerable increases in daily gain due to pelleting in both of two experiments. However, a substantial feed saving occurred only in their first experiment. They also fed a corn ration in pelleted and in meal form, but did not improve rate or efficiency of gain by pelleting.

Later, in 1955, North Dakota workers compared pelleted barley rations with pelleted corn rations. In both of their two experiments they took advantage of the protein contribution of the barley and used smaller amounts of protein supplemental feeds than had been used in previous experiments.

The results of their first experiment showed that pigs fed the pelleted barley ration during the early part of the growing-finishing period gained as rapidly and efficiently as did pigs fed a pelleted corn ration.

Heavier weight pigs were used in the second experiment with those fed the pelleted barley ration gaining approximately 11 percent slower and requiring 11 percent more feed than those fed the pelleted corn rations. The daily gains of both lots of pigs were exceptionally good.

The North Dakota group in 1956 simplified their barley ration even more (95.2 percent ground barley, 1.5 percent blood meal, 1.5 percent meat scraps, 1.2 percent ground limestone, 0.5 percent trace mineral salt, and 0.1 percent vitamin supplement). Pigs fed a thin barley ration in pelleted form gained 18.5 percent more rapidly on 21.3 percent less feed than pigs fed the same ration in meal form. When plump barley was used, gains were increased 12.6 percent and feed requirement was reduced 30.8 percent due to pelleting. Dinusson and D. W. Bolin in 1958 reported that the improvement in rate and efficiency of gain was apparently due to the pigs ingesting more of the pelleted than of the meal ration. In this instance, they fed the ration as meal, pellets, reground pellets in meal form, and crumbles. The most rapid and efficient gains resulted from the pelleted ration.

Minnesota Studies—D. Reimer and his colleagues at the University of Minnesota in 1958 reported on the first of a series of experiments conducted at the Northwest Experiment Station, Crookston. They, too, found pelleting of barley rations to cause a substantial reduction—52 pounds—in the feed requirement per hundredweight of gain. Their results show that pigs fed a pelleted barley ration similar to that used by Dinusson gained 8 percent less rapidly and required 7 percent more fed than pigs fed a meal ration based on ground yellow corn and soybean meal. Their corn ration contained approximately 13.4 percent protein, while the barley ration was estimated to contain approximately 12.6 percent. Both rations would have been slightly sub-optimum in protein content for pigs averaging approximately 54 pounds as in this experiment.

Lysine and Methionine

Either lysine or methionine is the first limiting amino acid in barley. Reimer and his colleagues reported in 1959 the results of another experiment. In this they fed growing-finishing pigs several different rations including: (1) a meal ration based on ground yellow corn and soybean meal; (2) the North Dakota pelleted barley ration; (3) a pelleted ration based on barley and soybean meal; or (4) a pelleted ration with

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

Feed Service Committee—Harold B. Swanson, chairman; William Hueg; William Flemming; Lester Hanson; Hal Routhe; Curtis Overdahl; and Robert Berg. Maxine Larson, editorial assistant for the committee.

Recent Research In Poultry—

* Energy Evaluation

* Controlled Feeding

EDWIN P. SINGSEN

Energy Evaluation

Can metabolizable energy be used instead of the productive or net energy measurement to evaluate poultry feed ingredients? Many researchers have concluded that it is a more widely useful measurement and that it can be determined much more precisely than productive energy.

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F. W. Hill of Cornell says it is more convenient than measuring digestibility in poultry and can be determined at least as accurately. Determining metabolizable energy value is not greatly influenced by level of food intake, rate of growth, or hormone treatment. Age is a factor in only certain specific cases. Nutrient balance must be reasonably sound for either measurement or misleading data may result.

At first there weren't enough data to encourage the use of metabolizable energy in making practical poultry feeds. This situation has gradually been corrected. For several years, Cornell University, under the direction of F. W. Hill, and the University of Connecticut under L. M. Potter and L. D. Matterson, have conducted extensive experiments. The published results, plus some current unpublished data from Connecticut, have been assembled and averaged in table 1. Footnotes indicate how data were calculated.

Table 1. Metabolizable energy values of feed ingredients for chickens*†

Ingredient	Avg. metabolizable calories (per pound)*		
	Connecticut	Cornell	Combined average
Alfalfa meal (15 percent)	290	..	290
Alfalfa meal (18.5 percent)	490	620	555
Barley	1,130	1,280	1,205
Barley, pearled	....	1,130	1,130
Barley hulls	....	350	350
Bread meal	1,640	..	1,640
Corn cobs	....	240	240
Corn, No. 2 yellow	....	1,560	1,560
Corn, ground yellow	1,445		1,445
Corn millfeed	....	1,470	1,470
Corn, gr. white degermed, debranned	1,630	....	1,630
Corn gluten meal	1,440	1,510	1,475
Corn oil	4,000	3,950	3,975
Distillers dried grains, corn	740	....	740
Distillers dried grains with sol., corn	1,110	....	1,110
Distillers dried solubles, corn	1,222	1,277	1,250
Fat, hydrolized animal and vegetable	....	3,230	.
Fat, poultry	3,723	....	3,723
Feather meal	1,078	....	1,078
Fermentation product, antibiotic	400	....	400
Fish meal, menhaden (59-64 percent)	1,161	1,307	1,234
Fish meal (60 percent) (19 percent fat)	1,576	....	1,576
Fish oils	....	3,660	3,660
Glucose	1,486	1,486	1,486
Hominy feed	1,380	1,350	1,365
Lard	....	3,980	.. .
Meat scrap (50-55 percent)	....	871	871
Meat and bone scrap (44 percent)	810		810
Milo, ground	1,530	1,480	1,505
Molasses, blackstrap	....	890	890
Oats, ground	1,140	1,190	1,165
Oats, hulless (Vicar)	....	1,540	1,540
Oat hulls	....	150	150
Oats, rolled	....	1,450	1,450
Poultry by-product meal	1,258	....	1,258
Rye (tetrapetkus)	....	1,300	1,300
Soybean hulls	....	5	5
Soybean oil meal (44 percent)	1,020	1,020	1,020
Soybean oil meal (50 percent)	1,090	1,150	1,120
Soybean millfeed low protein	....	350	350
Soybean millfeed high protein	....	570	570
Soybean oil, degummed	....	4,210	4,210
Soybean soapstock	....	3,150	3,150
Starch	1,680	....	1,680
Sucrose	1,670	....	1,670
Tallow, feed grade	3,190	3,230	3.210
Tallow, pure beef	....	2,860	2,860
Wheat, ground	1,320	1,490	1,405
Wheat, bran		510	510
Wheat, flour	1,390	....	1,390
Wheat, flour middlings	....	1,200	1,200
Wheat, red dog	....	1,240	1,240
Wheat, standard middlings	960	810	885
Whey, dried	906	830	868
Yeast, dried brewers	840	....	840

* The combined average data were computed from a number of recent publications from Cornell University and the University of Connecticut. Potters *et al.*, Storrs Agricultural Expt. Sta. Progress Report 39 (revised), 1961.

† All data calculated to an air-dry basis assuming 10 percent moisture for all ingredients, except corn (15 percent), molasses (20 percent), and whey (5 percent). Glucose, sucrose, fats, and oils were assumed to be moisture free.

The 10 samples of ground yellow corn assayed at Connecticut ranged in value from 1,370 to 1,511 calories per pound compared to 1,560 given by Hill for No. 2 yellow corn. With one exception, the Connecticut samples were purchased on the open market as "ground yellow corn," yet their energy content is closer to Hill's value for corn millfeed than to No. 2 yellow corn. This suggests that the value of 1,460 calories per pound is more realistic for ground corn, as used in practical feeds.

The value for tallow is based on the very young chick and, according to Ruth Renner and Hill, will increase approximately 10 percent for chickens 8 weeks of age and older. Age apparently does not effect the utilization of corn oil or lard by the growing chick.

Hill also has reported that most basic grains show relatively uniform metabolizable energy values. He also reports that wheat by-products and oats show the expected decline in metabolizable energy content, as the crude fiber content increases.

In contrast to the uniformity obtained with the grains, L. M. Potter and associates at Connecticut found that 6 samples of corn distillers dried solubles varied from 952 to 1,400 calories per pound. Six samples of menhaden fish meal ranged from 985 to 1,231 calories per pound, and 2 samples of 60 percent protein fish meal containing 19 percent fat averaged to contain 1,576 calories per pound.

It is obvious, therefore, certain ingredients vary greatly depending largely upon their content of crude fiber and/or fat. Table 1 averages are based on enough samples, however, so that they can be used with confidence in formulating and evaluating practical feeds.

Controlled Feeding

As a general rule, energy needs appear to regulate energy intake, and poultry adjust their feed consumption according to the concentration of energy in the feed.

Hill has reported an excellent example of this adjustment by adult lay-

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Barley —

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soybean meal and fish meal (approximately 2:1) supplying the supplemental protein. All rations except the North Dakota one contained approximately 15 percent of protein until the pigs weighed 100 pounds. At that time the protein content was reduced to 12-13 percent. The North Dakota ration contained 13.3 percent of protein and was fed throughout the experiment.

The pigs fed the pelleted barley rations with either soybean meal or a combination of soybean meal and fish meal gained as rapidly and efficiently as did pigs fed the ration based on corn.

The replacement of a part of the soybean meal with fish meal resulted in the largest daily gains but did not improve efficiency of feed utilization.

When the ration containing 13.3 percent of protein was fed continuously throughout the experiment rate of gain was depressed with one group of pigs and feed requirement was increased. A 13.3 percent pelleted barley ration appears to be barley adequate in lysine—and all present may not have been available—and it may have been slightly inadequate in methionine plus cystine.

On the other hand, the rations with soybean meal or a combination of soybean meal and fish meal both supplied more than the required amounts of the three amino acids. The response in the daily gain of the pigs fed the ration containing a small amount of fish meal may have been due to the increased amounts of lysine and methionine plus cystine as well as to more total amino acids being available to the pig thus enabling it to meet its requirement for these amino acids.

Pelleted barley rations containing only small amounts of supplemental protein can be adequate in the critical essential amino acids if care is exercised in the selection of the protein supplemental feeds.

Subsequent comparisons have been made at the Crookston Station, University of Minnesota to compare two things: (1) sources of supplemental protein—all selected to supply high lysine—to barley and (2) the feeding of a 16 percent protein ration until the pigs reached 100 pounds and 13 percent protein rations thereafter vs. the continuous feeding of 14 percent protein rations using the same sources of supplemental protein. In all cases the rations were fed in pelleted form.

Rate of gain was not substantially influenced by the use of either source or combination of protein supplemental feeds or by protein content of the diet. The use of soybean meal as the sole source of supplemental protein resulted in as efficient, or more efficient, gains as did any of the combinations.

Reimer and associates in 1961 also reported another experiment in which they compared the feeding of pelleted barley rations containing approximately 15 or 14 percent of protein initially, 12 and 11 percent, respectively, after pigs weighed 100 pounds, with the continuous feeding throughout the growing-finishing period of rations containing approximately 13 or 12 percent of protein. In this study they used soybean meal alone, and combinations of soybean meal tankage at ratios of 1:2 and 2:1, and tankage alone. All rations were self-fed to the pigs in concrete drylot pens and fresh water was supplied at all times.

Rations used in this study, as with other studies at the Crookston Station, were adequate in all nutrients other than possible deficiencies in total protein, lysine, and methionine plus cystine.

This experiment was intended to determine whether tankage alone would be as satisfactory a source of supplemental protein as soybean meal alone or soybean meal in combination with tankage. The tankage rations generally would have contained more lysine and slightly more methionine plus cystine than equivalent protein rations based on soybean meal alone. However, a lack of availability of the lysine, or other amino acids, from the tankage could make it a less satisfactory protein supplement—source of amino acids—than other protein supplements used in the investigation.

Generally, the pigs fed the rations containing approximately 15 percent of protein initially and 12 percent after the pigs weighed 100 pounds made more rapid gains than did those fed rations containing less protein.

Soybean meal alone was an excellent supplement to barley in this investigation, promoting the most rapid gains.

A combination of 2 parts soybean meal and 1 part tankage also supplemented the pelleted barley rations very well with gains being only slightly less than those of pigs fed the barley-soybean meal rations.

Tankage alone was a satisfactory supplement to barley in pelleted rations with the exception of the ration containing 12 percent of protein and fed throughout the experiment.

Supplementing with Amino Acid

Barley varies widely in protein content, and many samples may contain considerably more than 12 percent protein. As a result considerable interest is being shown in amino acid supplementation of rations based on barley, minerals, and vitamins. In 1961 we conducted work at Minnesota using barley containing 13.3 percent protein.

Ration with 13.39 percent protein—This barley was supplemented with minerals and vitamins to make it adequate with respect to these nutrients. Urea was then added to provide sufficient nitrogen (protein equivalent) to provide a ration containing 14 percent of dietary protein. This ration was then supplemented with 0.10 and 0.20 percent of DL-methionine, or with 0.15 and 0.30 percent of L-lysine monohydrochloride, or with the possible combinations of the two amino acids.

Three weanling Yorkshire pigs were individually fed each of the experimental rations for 49 days. The pigs fed the basal rations gained approximately 1.0 pound daily. Best gains came when the ration was supplemented with a combination of 0.3 percent L-lysine and 0.10 percent DL-methionine (1.35 pounds daily) and with 0.3 percent of L-lysine alone (1.27 pounds daily). The 0.10 percent of DL-methionine alone and in combination with each of the levels of L-lysine gave slight responses. The use of 0.2 percent DL-methionine appeared to depress performance from that obtained with the 0.1 percent level, possibly due to amino acid imbalance.

Further work is necessary to determine whether the addition of other amino acids will provide as rapid and efficient gains as realized with wholly adequate rations based entirely on natural feed-stuffs.

Ration with 14 percent protein—A 14 percent protein ration based on the 13.3 percent protein barley and soybean meal was also used. Again, 3 weanling Yorkshire pigs were individually fed each of the experimental rations for 49 days. The amino acid additions in this experiment were: 0.1 or 0.2 percent DL-methionine, 0.15 percent L-lysine monohydrochloride, and the possible combinations of these amino acids. One group of pigs also was fed a ration to which 0.3 percent L-lysine was added.

Rate of gain and efficiency of feed utilization were not improved due to either level of supplemental methionine or due to the use of methionine in combination with 0.15 percent L-lysine.

Efficiency of feed utilization was improved approximately 5 percent due to the addition of 0.15 percent of lysine

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Recent Research—

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ing hens. Here hens showed a tendency toward higher egg production with higher energy levels, but, except for the lowest energy concentrations fed, showed essentially the same total energy intake on all rations.

Connecticut, however, reported an exception in that heavy broiler-type breeding hens consume energy greatly in excess of their body needs when fed a high-energy ration containing supplemental fat. Apparently these birds can't regulate intake as well and so they become very fat and have a higher death rate. Controlling their energy intake on the basis of body weight, egg production, and environmental temperature resulted in a marked increase in efficiency of egg production and a sharp reduction in mortality.

People have objected to controlled feeding because of the work involved in weighing feed given to each pen daily, and sampling body weight every other week or every month. Connecticut however, has developed a simplified controlled feeding system for broiler type feeders, in which the birds are weighed only once, about 2 weeks after they have reached peak egg production. Subsequent changes in daily feed allowance are based on egg production and temperature changes only. Although the birds control-fed the high-energy ration gain slightly more weight than anticipated, they laid as many eggs as birds full-fed group.

Another approach to a simplified controlled feeding system, which we have now tested for 2 years, has been a "skip-a-day" program. This eliminates both weighing the birds and the feed. All birds are full-fed a high energy all-mash ration from housing time until 2 weeks beyond peak egg production. The skip-a-day system was then initiated.

During the first year it consisted of withholding all feed for a 24-hour period, 8:00 a.m. one day to 8:00 a.m. the next, every third, fifth, or seventh day. Full-fed birds served as controls, and all birds received 1 pound of wheat per 100 birds per day in the litter to help litter management. Withholding all feed for 24 hours every fifth or seventh day did not affect egg production or feed intake over a 32-week period, but skipping 1 day in 3 lowered egg production approximately 5 percent.

Average hatchability increased consistently in all groups on the skip-a-day system, approximating 74 percent, 76 percent, 79 percent, and 80 percent, respectively, for birds that were full-fed, skipped 1 day in 7, 1 in 5, or 1 in 3 in the first experiment.

Table 2. Results with a simplified controlled feeding system* (40 weeks) Connecticut, 1960

	Trial: Low energy	Trial: High energy	Controlled high energy
Avg. body weight			
Start	6.95	6.94	7.01
Finish	7.36	7.90	7.81
Eggs per bird	151	146	150
Feed consumed (pounds)	95.5	84.4	77.7
Feed per dozen eggs	7.58	6.92	6.23

* Broiler-type White Plymouth Rocks.
Low energy diet—approximately 1,153 calories metabolizable energy per pound.
High energy diet—approximately 1,321 calories metabolizable energy per pound.

During the second experiment, full feeding was compared only with skipping every fifth day. Feed intake, body weight, mortality, and egg production were not affected, while hatchability averaged 4.08 percent higher for the birds on the skip-a-day treatment.

Barley—

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and nearly 14 percent due to the addition of 0.3 percent of lysine.

Rate of gain was not affected by 0.15 percent of lysine, but the addition of 0.3 percent of the amino acid resulted in an 11 percent increase in daily gains. Those pigs fed rations based on barley and soybean meal gained about 15 percent more rapidly, but no more efficiently than those fed barley-urea rations.

All rations used in these studies were fed in meal form so that feed intake may not have been as high as experienced with pelleted barley rations. As a result, the maximum average daily gains are somewhat below those with pelleted rations, and the feed requirements are slightly higher. Generally, the rations containing the higher level of supplemental lysine would have contained more total lysine than other rations containing 15 percent of protein and reported to have given excellent results in other studies.

Feed Cost Important—

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pretation of the total data that they would eventually grow "around" their rumens, and the capacity would regress towards the size indicated for mature cows. Certainly the facts are not all at hand and further work is indicated.

Of particular interest is the fact that the milk fed calves, even during the early weeks, had capacities which were greater per unit of weight than at birth. This is particularly true of those at 16 weeks which consumed no bedding. This indicates that the rumen has an inherent growth potential that is unrelated to diet.

Practical Considerations

These studies were originally intended to obtain basic information that would be useful in the feeding of developing ruminants. They have not, at this stage, resulted in data which would revolutionize present practices. They have, however, resulted in a better understanding of the type of process with which we are dealing.

The single most important factor that initiates ruman development is dry feed consumption, either hay or grain. Our studies have shown the period of greatest change in dairy calves is between 4 and 7 weeks of age. This coincides with the time when milk feeding is declining and dry feed consumption is increasing. There appears to be no reason to discriminate against grain feeding in terms of developing rumen structure although it may under certain conditions be sounder economics to limit it.

In suggesting a calf feeding program our data suggest that the quality of the forage available, the relative cost of the milk, milk replacer, grain or hay, and the rate of grain desired by the feeder are more important criteria than the need to develop the rumen.

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

AGRICULTURAL EXTENSION SERVICE
Institute of Agriculture
University of Minnesota
St. Paul 1, Minnesota
SKULI RUTFORD, Director
Cooperative Agricultural Extension Work, Acts of May 8 and June 30, 1914.
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