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NUTRIENTS, FEEDS AND EXAMPLE RATIONS FOR SWINE

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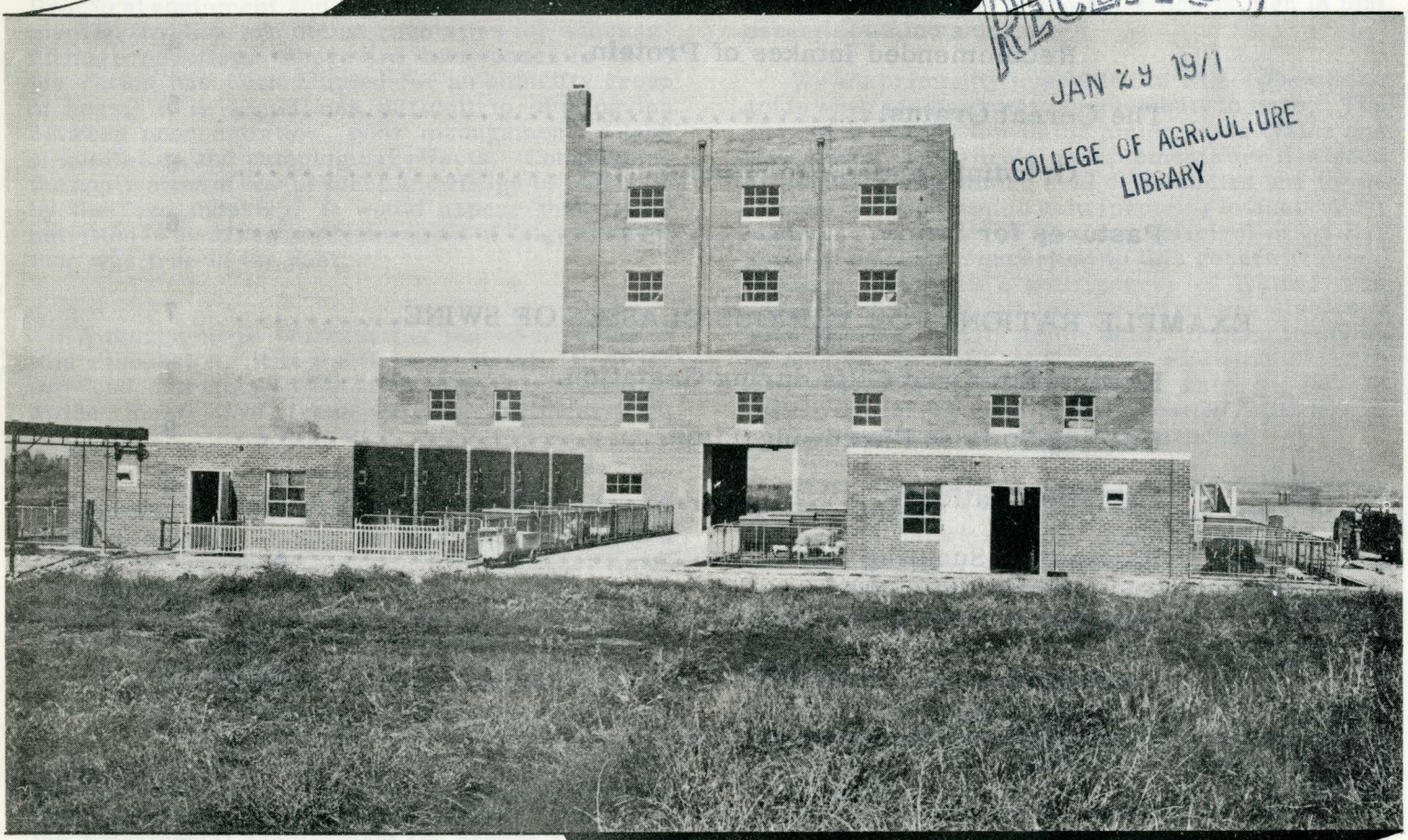

Swine Research Center
College of Agriculture, Lincoln

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NUTRIENTS, FEEDS AND EXAMPLE RATIONS FOR SWINE

Merle J. Brinegar and Donald R. Warner

The same principles of nutrition apply to swine feeding, whether the producer buys ready mixed complete rations, mixed supplements to add to home grown grains, or prefers to mix complete rations or supplements using the basic ingredients. The following discussion is intended to aid the swine grower in selecting a ready mixed product suited to his needs and to serve as a guide in mixing rations for swine. The program which should be followed will depend to a large degree on the extent of the swine enterprise, the availability of equipment for properly mixing ingredients and the knowledge of feeds and nutrients.

It should be recognized that the best nutrition will not compensate for a lack of good management. Practical equipment and sound systems of management and hygiene are prime requisites for successful hog production. There are many cases in which the ration has been blamed for an unthrifty group of hogs. It is sometimes difficult to distinguish between poor nutrition, poor management, a lack of sanitation and pathological effects. Considering the application of our present knowledge of nutrition by the feed industry, it would appear that faulty nutrition is less frequently the cause of "pig troubles" than was true in the past.

Although little emphasis is placed on water in this discussion, it is the first essential. In order for feed nutrients to be utilized at a maximum, swine must have fresh water before them at all times.

Present economic conditions dictate that the most profitable swine venture usually follows a pattern of raising the most meat in the least time. Circumstances sometimes warrant deviation from such a procedure, but a knowledge of swine nutrition will be of equal importance in any type of program.

NUTRIENTS and FEEDS for CONSIDERATION

A basic rule of nutrition is that each essential nutrient must be present in an adequate amount for other nutrients to be properly utilized. Energy is the fundamental requirement for growth and maintenance. Many other nutrients are required for the utilization of energy and the formation of meat and bone.

Feed ingredients can be grouped into two general classes: (1) Protein supplements and (2) the cereal grains. Protein supplements serve not only as sources of protein but, in addition, are important sources of other essential nutrients. A consideration of these nutrients individually will be of value in determining the usefulness of a protein supplement.

Proteins

All proteins consist of compounds called amino acids. The purpose of protein in a diet is to furnish the animal with the amino acids necessary for building body protein. There are more than 20 of these amino acids. The distinguishing characteristics of different proteins are the kinds and proportions of the different amino acids and the manner in which they are combined to form protein. Any amino acid in one protein is exactly like the same amino acid in another protein. However, the two proteins may contain different amounts of the amino acid. If a particular protein is low in an essential amino acid, the protein will not be utilized efficiently unless it is combined with a protein which is high in that essential amino acid.

We are primarily interested in two of the amino acids when adding protein supplements to corn. The protein in corn is low in the amino acids lysine and tryptophan. Good protein supplements are designed to correct these amino acid deficiencies and to increase the total amino acid (protein) intake. Most proteins of plant origin are deficient in lysine. Soybean meal is an exception to this generalization. Soybean protein is a good source of lysine. The proteins of animal and marine origin are also very good sources of this amino acid. If plant proteins other than soybean meal serve as supplements to corn for swine, another protein which is high in lysine should be used in combination with them. Animal proteins can serve this purpose.

Most supplements containing several proteins furnish enough tryptophan to counteract the deficiency in corn protein. Some samples of meat and bone scraps, if fed alone with corn, will not furnish sufficient tryptophan for maximum growth. The plant proteins are good sources of tryptophan.

Vitamins

There is nothing magic about the vitamins. Swine received them long before we knew they existed. However, swine might fail to receive vitamins in adequate amounts if their diets do not consist of proper combinations of ingredients.

In most cases, the vitamins are parts of enzyme systems which function in the utilization of proteins, fats, carbohydrates and minerals and serve in the maintenance of various body tissues. Animals have specific physiological requirements for these nutrients. Extra amounts over those needed for the definite body processes are of no value to the animal, except that a few of them may be stored in the body for future needs. This may result in waste. It is more sound practice to supply the vitamins in the amounts needed at the time needed. The primary concern is to supply enough of the necessary vitamins.

An impressive list of the vitamins required by swine can be made. Only a few of these are likely to be deficient in the majority of swine rations made from any combination of natural feedstuffs. Deficiencies of these will seldom occur if correct combinations of ingredients are used.

Vitamin A. Only two classes of swine feed have appreciable vitamin A value. Green leafy forage crops and yellow corn and some of its by-products are good sources. Vitamin A is formed in the body from the carotene in these feeds. Dehydrated alfalfa meal is an excellent source of carotene. Bleached hay and feeds which have been stored for considerable time contain less carotene. Fish liver oil or synthetic sources of vitamin A are available for rations low in vitamin A value. Rations containing yellow corn and good quality alfalfa hay or meal are usually adequate. Some symptoms of a vitamin A deficiency in swine are slow growth, a lack of coordination and dead, weak or malformed pigs at birth.

Vitamin D is necessary for the utilization of calcium and phosphorus in bone formation. A deficiency causes rickets. If correct levels of calcium and phosphorus are present in the diet, a vitamin D deficiency will not occur under most conditions of swine feeding. Only pigs kept away from sunlight are likely to exhibit deficiency symptoms. Since irradiation of the body by the sun produces vitamin D from precursors in the skin, swine kept outside in the summer months will never become deficient in this vitamin. If kept indoors or if exposed to less sunlight during the winter months, good sun-cured alfalfa hay, cod liver oil, irradiated yeast or irradiated sterols will provide adequate intakes. Dehydrated alfalfa contains very little vitamin D.

Vitamin E. It has been shown that vitamin E is necessary for successful reproduction in rats. At present, there is no evidence showing any improvement in the reproduction of swine from supplementing natural diets with vitamin E. Green pastures, good quality alfalfa hay or meal and the cereal grains are good sources of vitamin E.

Vitamin B_{12}. This recently identified vitamin is concerned in some way in the protein metabolism of animals and in the formation of the red blood cells. Feeds of plant origin are deficient in vitamin B_{12}, while feeds of animal and marine origin are good sources of this factor. Diets containing no, or very little, animal protein should be supplemented with vitamin B_{12}. Excellent sources of this vitamin are supplements produced by microbial fermentation. The term APF (animal protein factor) is sometimes used to designate a nutrient or group of nutrients which include vitamin B_{12} and possibly some unidentified vitamins. The term APF has been officially discarded.

Riboflavin. Some deficiency symptoms of riboflavin in swine include slow growth, diarrhea, stiffness and a general unthrifty appearance. Litters from riboflavin-deficient sows may be farrowed several days prematurely and show deformities. The cereal grains and most of their by-products are low in riboflavin. The oil meals and most meat by-products are better sources but cannot be relied upon to correct the deficiencies of the grains. Alfalfa, milk products, brewers' yeast and distillers' solubles are rich sources (see table 8). Fermentation solubles and riboflavin from synthetic sources are available for supplementing rations containing inadequate amounts of the above ingredients.

Pantothenic Acid. Swine deficient in this vitamin grow slowly, may have a scurfy skin condition, diarrhea and show a characteristic incoordination (goose stepping). Corn and some by-products are poor sources of this vitamin (see table 8). In general, protein supplements of plant origin contain more pantothenic acid than tankage or fish meal. Alfalfa, milk products, brewers' yeast, peanut meal and wheat bran are good sources of pantothenic acid. Goose stepping has been noted in pigs (in dry lot) fed rations containing alfalfa meal. Some samples of alfalfa meal at levels normally fed in dry lot may not furnish sufficient pantothenic acid to compensate for the relatively low levels in corn and several of the protein supplements. Synthetic sources of this vitamin are available for use in rations consisting of feeds low in pantothenic acid.

Niacin. A deficiency of niacin may result in slow growth, vomiting, a rough skin condition and diarrhea. Certain types of diarrhea of nutritional origin respond to niacin therapy. The requirement for niacin can be easily supplied by a correct combination of ingredients. Corn, oats, rye and the milk products are among the poorest sources. Numerous other feeds supply considerable niacin (see table 8).

Several other known vitamins are required by swine, but grains and protein supplements supply enough of these vitamins under nearly all conditions. Recent research indicates that one or more unidentified growth factors may be required by swine. It is unlikely that correct combinations of ingredients in swine rations and the wise use of good pastures will fail to supply adequate levels of these factors.

Minerals

Under most conditions of swine feeding, calcium is the mineral element which should receive major consideration. The cereal grains are exceedingly poor sources of calcium. Protein supplements of plant origin make only minor contributions of calcium. The packing house by-products, fish meal, milk and alfalfa are good sources. Phosphorus levels are less critical in most rations. Although the grains supply more phosphorus than calcium, some unsupplemented diets may be deficient in phosphorus. For rations low only in calcium, ground limestone is a satisfactory supplement. Steamed bone meal and low-fluorine calcium phosphates are good supplements for supplying both calcium and phosphorus. The calcium phosphates should not contain more than 0.4% fluorine, since this mineral element is toxic at higher levels.

Salt (sodium chloride) is very important in swine rations. Swine rations should contain about one-half pound salt per 100 pounds. If the salt is included in the protein supplement only, it should be added at the rate of approximately 2 pounds per 100 pounds of supplement.

Additional quantities of some of the "trace minerals" should be supplied to swine under certain conditions of feeding. Iodine may be low in areas where the soil is deficient. The use of stabilized iodized salt is a good practice. A deficiency of iodine will cause goitrous, hairless newborn pigs.

A deficiency of iron or copper will cause anemia in pigs. Since milk is low in these elements, baby pigs kept away from the soil should be supplied with additional iron and copper. A satisfactory method of furnishing these elements is to swab the sow's udder with a saturated solution of iron sulfate, called copperas (one pound per gallon of water). Since large doses of iron are absorbed inefficiently, the sow's udder should be swabbed daily. Supplementing the sow's ration with iron and copper is not effective in increasing these elements in the milk above normal levels.

The results of some experiments indicate that the supplementation of certain dry lot rations with cobalt will increase gains. Vitamin B_{12} contains this element. It is possible that such growth stimulation is due to an interrelationship between cobalt and vitamin B_{12} in a diet low in this vitamin.

There is no evidence at present indicating the need for supplementing rations with trace minerals for pigs receiving good pasture. Since the trace minerals are rather inexpensive, the swine producer may wish to include them in his ration as an insurance measure. They can be supplied by using a "trace mineralized" salt or by feeding an inexpensive "complex" mineral mixture. Such a mineral mixture can be satisfactorily self-fed to supply the mineral needs of swine.

Antibiotics

Recent reports have shown that the addition of some of the antibiotics to good swine rations increases gains and feed efficiency. Most of the tests have been made with pigs in dry lot. Some pasture experiments have been reported. Many more experiments are needed before all of the answers are known but a few general statements can be made.

Antibiotics are drugs and not nutrients. We cannot expect as uniform response in gains of swine fed the antibiotics as we can in the case of nutrients which are required physiologically in definite amounts. There is a proportionately greater increase in gains of young pigs fed antibiotics than in animals near market weights. Although some apparently healthy pigs respond to antibiotic feeding, the benefit is usually greater for unthrifty pigs. The response of pigs on good pasture to antibiotic feeding is less than that of similar pigs in dry lot. Pigs that respond to antibiotic feeding usually consume more feed, leaving a greater proportion of the intake available for growth after the maintenance needs are supplied. In many cases, feeding the antibiotics decreases the incidence of some types of diarrhea. Feeding the antibiotics at economical levels will not, by any means, prevent or cure all types of diarrhea.

Whether feeding the antibiotics has an unfavorable effect on the proportion of lean to fat cuts in a carcass has not been studied adequately. It seems reasonable to expect that the carcasses of our present types of hogs reaching market weight at an earlier age may contain more fat.

The effectiveness of several of the antibiotics has been studied. Aureomycin and terramycin have been tested extensively with favorable results. Penicillin, bacitracin, streptomycin and other antibiotics have also been studied. It appears that streptomycin is less effective at similar levels than some of the other antibiotics. In some tests, penicillin has compared favorably with the other antibiotics. It is difficult to make direct comparisons because levels of antibiotics used in some experiments have not been equalized. Only a few results have been reported for bacitracin. Whether it will compare uniformly with the other antibiotics is not definitely known. Combinations of antibiotics have also been effective in increasing gains, but at present, few results of such experiments are available.

Some experimental results show that certain arsonic acid derivatives stimulate the growth of swine under certain conditions, probably in a manner similar to that of the antibiotics. Growth stimulation from these arsenicals appears to be less than from the more effective antibiotics when added to antibiotic-free rations. In some experiments the arsenicals have produced symptoms of toxicity.

Several theories have been proposed as to how the antibiotics exert their influence. One theory is that they retard the growth of harmful intestinal bacteria. This may either allow beneficial bacteria to multiply and have a favorable effect on the animal or may merely clear up a low grade infection which may or may not be outwardly noticeable. A second theory is that the comparatively low levels of antibiotics required to increase growth actually stimulate the growth of beneficial bacteria. A third theory is that the antibiotics kill bacteria which may compete with the animal for certain nutrients which increase growth. It is probable that a combination of factors is involved.

The question frequently arises as to the advisability of including antibiotics in the gestation or lactation rations of brood sows. According to our present knowledge, the swine producer who adds antibiotics to sow rations during gestation and lactation should not expect enough extra pounds of pigs at weaning time to pay the extra cost of the antibiotics. The inclusion of antibiotics in rations for suckling pigs is another problem. Numerous experiments have shown considerable benefit from supplementing creep rations with antibiotics.

Even though many swine producers can expect increased gains from feeding antibiotics (especially in dry lot), it should be emphasized that these compounds will not take the place of proper nutrition and sanitation. More information is needed before the routine practice of feeding antibiotics can be accurately evaluated.

Supplements are available which contain antibiotics, antibiotics and vitamin B_{12}, antibiotics and several vitamins, or antibiotics, several vitamins and minerals. The swine producer who uses plenty of good pasture, dehydrated alfalfa meal or excellent quality ground alfalfa should be interested primarily in the antibiotic and vitamin B_{12} content of such supplements. If, in addition, considerable protein of animal origin is used, the vitamin B_{12} content should receive little attention.

Any statements regarding the levels of antibiotics for feeding are only estimates at the present. It should be expected that the optimum levels of the different antibiotics will vary under different feeding conditions and systems of management. A tentative guide is to feed the equivalent of 10 grams of antibiotic per ton of mixed feed for pigs between weaning and 125 pounds. For pigs from 125 pounds to market weight, a more economical level is probably nearer 5 grams of antibiotic per ton of mixed feed. If antibiotic is included in the protein supplement (containing 35% to 40% protein) only, the level of supplementation should be from 30 to 40 grams per ton of supplement. For example, if a pound of an antibiotic supplement contains 5 grams of antibiotic, 6 to 8 pounds of the product should be added to each ton of protein supplement. Such a procedure will automatically provide higher intakes of antibiotic during the early growth period.

For suckling pigs, antibiotic levels in relation to grain and supplement should probably be increased, since these feeds are only part of the total feed consumed. In addition, this period of the pig's life is more critical and cost is a less important factor. For creep rations, the level of antibiotic should probably be increased to 20 grams per ton of grain and supplement.

Market Stock

Weight	Protein in Ration
50 lbs.	18%
100 lbs.	16%
150 lbs.	14%
200 lbs.	13%
250 lbs.	12%

Miscellaneous Factors for Consideration of Protein Supplements

There are considerable differences in the palatability of the ingredients which may be used in protein supplements. Much of the unpalatability of various feeds is probably due to nutrient deficiencies. If these deficiencies are corrected, very few ingredients are unpalatable enough to prevent adequate intakes of protein. Swine allowed soybean meal free choice with grain will consume much more protein than is necessary to balance the ration. If soybean meal is mixed with an equal part (by weight) of another supplement or with one-third alfalfa meal, swine will usually not eat excessive amounts.

The energy contribution of protein supplements should not be overlooked, even though the cereal grains furnish the greater proportion of energy in rations. Some of the important sources of vitamins in supplements are either relatively low in protein or high in fiber (alfalfa, for example). However, care should be taken to exclude fibrous feeds that do not make definite contributions to the supplement. Excellent protein supplements containing adequate levels of vitamins can be compounded from natural ingredients and still contain 35% or more protein.

Recommended Intakes of Protein

The National Research Council Committee on Swine Nutrition recently reviewed the available experimental data on the protein needs of swine. The following levels of protein were recommended in rations for various classes of swine.

Breeding Stock

Class	Protein in Ration
Gestation-Gilts	15%
Gestation-Sows	12%
Lactation-Sows & Gilts	15%

It is recommended that young and mature breeding boars receive the same levels of protein as gilts and sows during gestation. As a general rule, about 2% less protein than the above levels is recommended in rations for swine on very good pasture. A few reports have indicated that the recommended levels of protein are higher than necessary. It is likely that swine will make good gains on diets containing lower levels of protein than those recommended, if the protein supplement is balanced with respect to amino acids, is highly digestible and contains adequate amounts of all known vitamins. For the present, the swine producer interested in maximum gains should feed the above levels of protein if economic conditions permit.

The Cereal Grains

Since corn is the most widely used of the cereal grains for swine, a discussion of these feeds might include the values and limitations of corn as a source of nutrients and its use as a yardstick in appraising the nutritive value of the other grains. Corn is an excellent source of energy, but it contains inadequate amounts of certain other nutrients as was emphasized in the previous discussion (see table 8). The small amount of protein in corn is of poor nutritive value. Supplements for corn should not only be designed to increase the protein intake, but, in addition, to correct the lysine and tryptophan deficiencies of corn protein (see previous discussion on proteins). Other cereal grains generally contain more tryptophan than corn.

Corn is deficient in some of the mineral elements. It contains very little calcium and only partly enough phosphorus. The levels of several vitamins in corn are also low. Yellow corn that has not been stored for a long period usually furnishes sufficient carctene (vitamin A value) for growing and fattening swine. Additional carotene must be supplied to brood sows. Good legume hay and green pasture are excellent sources. The carotene content of corn decreases during storage. White corn and the other cereal grains furnish little, if any, vitamin A value.

Soft corn can be utilized very efficiently by swine. Provided it is not moldy, corn with a high moisture content is usually equal to normal corn on the basis of dry matter content. Gains may not be as rapid, but feed utilization will probably be as efficient. The feeding value of corn containing 25% moisture should be worth approximately 88% as much as corn containing 15% moisture (75 : 85). The two samples of corn dried at moderate temperatures to the same moisture content should be of approximate equal value.

The value of soft corn is usually higher for hogs over 75 to 100 pounds than for younger pigs. The change from normal to soft corn should be gradual, in order to lessen the chances of causing scours.

Moldy corn may be worth considerably less than sound corn for hogs. Such corn may not be less palatable, depending on the type of mold, but the nutrient value may be decreased. Most of the molds of corn are not toxic to swine.

The most value from oats for swine can be obtained by including them in gestation rations for sows. Since a pound of oats furnishes about 80% to 90% as much energy as a pound of corn, their use in rations designed for rapid and efficient gains should be limited. Good quality oats are of almost equal value to corn, pound for pound, if they constitute as little as 1/4 of the ration (by weight).

Much of the satisfactory experience from including oats in swine rations is probably due to their higher content of protein which has a slightly higher nutritive value than corn protein and to their higher content of some vitamins and minerals than corn.

Hulled oats are in special favor for creep fed pigs. Young pigs seem to prefer them over most other feeds. The price of hulled oats is usually rather high, but the small amount consumed by suckling pigs and the benefit from feeding them may more than offset the extra cost.

Barley ranks about midway between oats and corn as a source of energy for swine. A pound of good quality ground barley is worth about 90% as much as a pound of corn for hogs. Barley is a much better source of niacin than either corn or oats but contains only slightly more riboflavin and pantothenic acid than corn. Barley infested with scab is unpalatable to hogs. If barley is very scabby, it should not be fed to hogs. If it is only moderately infested, it may sometimes be fed safely at no more than 10% of the ration. Even then, it should not be fed to brood sows or young pigs.

Most of the grain sorghums are worth from 90% to 95% as much as corn. They may be mixed with other grains or fed as the only source of grain.

Wheat is usually too high in price to warrant feeding it to hogs. Several tests have shown that wheat is equal to or gives slightly better results than corn. Wheat is higher in protein, niacin and pantothenic acid than corn.

In many tests, rye has not been entirely satisfactory as a swine feed. Rye infested with the ergot fungus will produce poor results. Ergot may cause abortion in brood sows. Some experiments have shown that good quality, disease-free rye is worth about 90% as much as corn. Best results are obtained when it is fed in combination with other grains and to hogs on pasture.

Grinding Grains for Swine

The following figures are estimated increases in feeding value which can be expected from grinding or rolling grains for swine

GRAIN*	IF HAND FED	IF SELF FED
Corn	5%**	Very little increase
Oats	25%	25%
Barley	20%	15%
Sorghum Grains	15%	3%**
Wheat	20%	5%**

*It usually pays to grind rye for swine.
**Will usually not pay for additional cost of grinding.

As a general rule, older hogs (brood sows and boars) do not chew the grains thoroughly enough to prevent waste. However, brood sows will usually chew corn from the cob sufficiently.

Pastures for Swine

The importance of good pasture for swine cannot be over-emphasized. The figures in table 8 emphasize a few of the important nutrient contributions of alfalfa. In addition to supplying more protein than the cereal grains, good pastures (especially legumes) are good sources of calcium and many of the vitamins.

Hogs will usually not gain more on pasture than similar thrifty hogs in dry lot fed a good balanced ration, however, less of the expensive supplements are required to balance the cereal grains. It has been estimated that an acre of good pasture utilized properly for hogs will save from 500 to 800 pounds of a good protein supplement. Pasture fed hogs require about one-half as much protein supplement as hogs fed in dry lot. Since pasture supplements need not contain alfalfa meal, they will usually cost approximately 25% more per pound than dry lot supplements. This amounts to approximately a 40% net reduction in the cost of protein supplement required to balance a ration for hogs on good pasture.

Swine on clean pasture are usually more thrifty than hogs in dry lot. A good sanitation program is much easier to carry out if pasture is utilized. In addition, less labor is required in caring for hogs on pasture.

Alfalfa is one of the most palatable and nutritious forages grown for swine. It provides excellent grazing from early spring until late fall. Depending on the many factors affecting the growth of alfalfa, one acre will usually be sufficient for 15 to 25 growing-fattening hogs or half this number of bred sows.

In areas where Ladino clover can be satisfactorily grown, it is fully equal to alfalfa as a pasture if it is not grazed too closely. In some tests it has been superior to alfalfa. It makes good growth during midsummer when some of the other pasture crops make less abundant growth.

Red clover approaches the value of alfalfa pasture for hogs. Its carrying capacity is slightly less and it is usually not ready for grazing as early in the spring as alfalfa. It is palatable to hogs if not allowed to become too mature.

Lespedeza is usually less palatable than alfalfa or red clover for hogs and cannot be grazed as early as these crops. Where it can be grown for hogs, the value of lespedeza is greatest for insurance grazing during the summer months.

Sweet clover is reasonably good pasture for hogs during the first year's growth. Hogs will eat much less of it than alfalfa pasture. However, considerable value can be obtained from sweet clover if pastured before it becomes too rank.

Rape is nearly equal to alfalfa or red clover for hogs. It is quite palatable and has the advantage of furnishing excellent pasture soon after seeding. It can be seeded early and is ready for grazing within 6 to 8 weeks. It furnishes pasture until late fall. Rape sometimes causes blistering in light colored hogs if grazed when wet. This is not a serious problem during the late summer months or if the plants are dry.

Sudan grass is very palatable to pigs. It is especially useful during the hot summer months when other pastures provide less forage. Because of its rank growth, it is best adapted to larger hogs. It is much more palatable if grazed closely. It is sometimes advisable to graze only part of the pasture and keep the remaining pasture clipped, if the carrying capacity exceeds the number of hogs.

Bromegrass is a very satisfactory pasture for swine. It supplies an abundance of early pasture and withstands rooting and trampling exceptionally well. Gains of pigs on bromegrass pasture are not as good as on alfalfa pasture. Its greatest value is during spring and fall in comparison to its decreased growth and palatability during July and August. Mixtures of bromegrass and alfalfa usually give as good results as alfalfa alone.

Rye is a very good pasture for fall pigs or bred sows during an open winter. Its best use is for early spring pigs before other crops are ready for grazing. It should be seeded at a heavy rate.

EXAMPLE RATIONS for VARIOUS CLASSES of SWINE

Table 8 shows the approximate content of several nutrients in feeds. The figures shown are intended as guides and not as absolute values for specific feeds. Considerable variation exists between different samples of the same feed.

By keeping the values and limitations of the grains in mind and recognizing the importance and sources of nutrients for swine, excellent diets can be formulated from a few simple feeds and supplements. Under certain conditions, some of the more expensive supplements may increase the performance of swine fed rations shown in the following tables. However, the cost of such supplements may not be offset by the increased performance. The value of certain "high potency" supplements for swine depends entirely on the adequacy of the ration to which they are added. For example, the value of milk products is considerably less for hogs receiving good alfalfa meal or pasture than for hogs receiving only the cereal grains and common protein supplements. Likewise, the value of milk products is greater for young pigs during the critical growth period than for hogs nearer market weight.

If no more milk is fed than is needed to balance the ration, it can be assumed that one gallon of liquid skimmilk or undiluted buttermilk is equivalent to approximately one pound of an excellent protein supplement. Excessive waste will be eliminated if no more than one gallon of skimmilk per head daily is fed to hogs in dry lot or approximately half this amount to hogs on good pasture. Liquid skimmilk contains approximately 10% dry matter. The value of other milk products can be calculated on the basis of equivalent amounts of dry matter.

Thorough mixing of diet ingredients cannot be over-emphasized. This is especially true of the ingredients needed in small quantities (for example, mineral, vitamin and antibiotic supplements). Inadequate mixing will not only result in waste of certain ingredients, but may also prevent some of the animals from receiving adequate intakes of some nutrients. If a small amount of an ingredient is added, it must be premixed with a larger quantity of some ingredient included at a higher level before it is added to the complete mixture. Even though feeds can be mixed satisfactorily by hand, the swine producer who practices "home mixing" extensively should have access to a good mechanical mixer.

Feeding Sows and Gilts During Gestation

An adequate ration during the breeding season and during gestation is necessary for brood sows to farrow strong healthy pigs. In addition to supplying nutrients for her own body processes and the unborn litter, it is important that she build up body reserves of nutrients for use during the drain of lactation. The adequacy of gestation rations can influence the survival and growth of suckling pigs.

TABLE 1. Types of Protein Supplements That May be Hand-Fed During Gestation.

	A	B	C	D	E	F	G
Approximate Protein Content	35%	35%	33%	34%	36%	37%	36%
			Weight - Pounds				
Soybean meal	300	300	300	200	300	400	300
Linseed meal	---	---	---	100	---	---	100
Tankage	300	200	---	200	300	---	---
Meat scraps	---	---	300	---	---	---	---
Fish meal	---	100	---	100	---	300	300
Distillers' solubles (dried)	---	---	---	---	100	---	---
Alfalfa meal (sun cured)	400	400	400	400	300	300	300
Ground limestone	20	20	10	20	35	40	40
Steamed bone meal	10	15	--	15	--	20	20
Salt*	20	20	20	20	20	20	20
Total	1050	1055	1030	1055	1055	1080	1080
	Ratios of above Supplements to Grain to Give 15% Protein						
Corn**	75	75	73	74	76	77	76
Supplement	25	25	27	26	24	23	24
1/3 oats and 2/3 corn	79	79	77	78	80	81	80
Supplement	21	21	23	22	20	19	20

*See discussion of minerals.
**One pound of dry ear corn is equivalent to approximately 0.8 pound of shelled corn.

The optimum gain in weight of sows and gilts during gestation depends on several factors. Gains should be regulated according to the age, type and weight of the sow. Sows that are bred when thin must receive extra feed to cover the additional gain required. Gilts must receive enough feed to cover both growth and developing litter requirements. In general, gilts should be expected to gain 100 to 125 pounds during gestation. Sows that are in good condition when bred should gain 75 to 100 pounds. As previously mentioned, deviations from these gains are sometimes desirable.

The amount of feed required for optimum gains depends on the bulkiness of the ration. Examples of supplements which may be fed with grain are shown in table 1. As a guide, it may be expected that mature sows will require approximately 1.2 pounds of feed per 100 pounds body weight daily during the initial 2/3 of the gestation period. During the last 1/3 of pregnancy, approximately 1.4 pounds daily per 100 pounds body weight should be fed. Bred gilts will require approximately 1.8 to 2.0 pounds of supplement and grain daily per 100 pounds body weight. On this basis a 350 pound gilt will require from 6.3 to 7.0 pounds of feed daily. Depending on the kind of grain fed, approximately 1/4 to 1/5 of this amount should be supplement (If the supplement contains 35% protein).

Some swine producers prefer to feed hay in the rack rather than include it in the protein supplement. The amount of hay consumed under such a system varies considerably. However, it can be assumed that sows and gilts will eat at least 0.5 to 1.0 pound of good quality hay per head daily. If a 350 pound bred gilt consumes 0.8 pound of hay daily, she should require only 5.5 to 6.2 pounds of supplement and grain. Since the supplement will be higher in protein, only 12 to 14% of the total feed should be supplement (supplements shown in table 1 without alfalfa). Accordingly, sows and gilts on good pasture do not require alfalfa in their supplement and thus require less total grain and supplement.

Satisfactory rations that can be self fed to sows and gilts during the breeding season and gestation are shown in table 2. These rations are bulky enough to prevent excessive fattening. The proportion of alfalfa in the rations can and should be varied to permit the gains desired (compare rations A and C). This method of feeding requires considerably less labor and prevents timid sows from receiving insufficient feed. Since the sows are not observed during feeding, it is exceedingly important that close attention is given them by a caretaker who can recognize sows that are "off feed". Another disadvantage is that many self feeders are not designed to handle bulky feeds and require considerable attention.

The rations shown in table 2 for mature bred sows are higher in protein than is necessary during gestation, since they contain what may be considered a minimum level of animal protein. If a vitamin B_{12} supplement is included in the ration it is not certain that the animal protein is necessary, however, future research may show benefit from such supplementation. If the tankage is omitted and the ration is supplemented with vitamin B_{12} very little extra protein is needed to balance the rations (10 pounds of soybean meal per 1000 pounds of ration).

TABLE 2. Types of Rations That may be Self-Fed During Gestation.

	Bred Gilts						Mature Bred Sows		
	A	B	C	D	E	F	A	B	C
	weight-pounds						weight-pounds		
Ground corn	400	320	360	360	510	---	360	310	460
Ground sorghum grain	---	---	---	---	---	430	---	---	---
Ground oats	250	300	250	250	---	200	300	300	100
Alfalfa meal (sun cured)	250	300	300	300	400	300	300	350	400
Tankage	50	40	40	---	40	40	40	40	40
Meat scraps	---	---	---	50	---	---	---	---	---
Soybean meal	50	40	50	40	50	30	---	---	---
Steamed bone meal	5	5	5	--	10	5	10	10	10
Salt*	5	5	5	5	5	5	5	5	5
Total	1010	1010	1010	1005	1015	1010	1015	1015	1015

*See discussion of minerals.

Feeding Sows at Farrowing Time

As soon as a sow is confined to her farrowing pen, feed should be decreased to correspond to her lessened activity and should have a slightly laxative effect. This can be accomplished by mixing about one part of wheat bran (by measure) with two parts of her regular ration. It is best not to feed the sow for 12 hours before and 12 hours after farrowing. During this time, she should have plenty of water.

On the second day she should receive about one pound of ration per feeding. The bulky gestation rations shown in table 2 are satisfactory during this period. The amount of feed should be increased daily until the sow is on full feed at the end of a week or ten days. If during this time the sow becomes restless, the ration can be made more bulky with wheat bran to satisfy her appetite. Overfeeding during the first two weeks may cause the pigs to scour. The presence of diarrhea is not a certain indication of overfeeding. During this period, pigs are very susceptible to many types of diarrhea caused by pathological conditions. As soon as the sow is on full feed of the bulky gestation ration she should be gradually changed to a more concentrated ration, such as one of those shown in table 3.

Sows and gilts can be self-fed immediately following farrowing if their energy intake is properly regulated by varying the amount of bulky ingredients.

Lactation Rations

By the time the pigs are 10 days or two weeks old, the sow should be self-fed a ration designed for maximum milk production. The rations shown in table 3 are suitable for self feeding during lactation. Very good results can also be obtained by feeding shelled corn or ground barley, wheat or sorghum grains and a protein supplement free choice. A satisfactory protein supplement is one containing equal parts of soybean meal, tankage and alfalfa meal with the addition of approximately 2% salt.

For sows suckling litters on good pasture, alfalfa meal can be omitted from the rations shown in table 3 and from protein supplements fed free choice with grain.

TABLE 3. Types of Rations for Self-feeding Sows and Gilts During Lactation.

	A	B	C	D	E	F	G	H*
			weight - pounds					
Ground corn	510	630	610	---	600	580	570	690
Ground sorghum grain	---	---	---	580	---	---	---	---
Ground oats	250	---	150	200	100	100	100	---
Wheat middlings	---	150	---	---	---	---	100	---
Alfalfa meal (sun cured)	---	---	100	---	150	150	100	150
Alfalfa meal (dehydrated)	100	100	---	100	---	---	---	---
Tankage	70	80	50	---	70	---	50	70
Meat scraps	---	---	---	60	---	70	---	---
Fish meal	---	---	40	---	---	---	40	---
Soybean meal	70	40	50	60	80	100	40	90
Ground limestone**	5	5	5	5	5	---	5	5
Salt***	5	5	5	5	5	5	5	5
Total	1010	1010	1010	1010	1010	1005	1010	1010

*This type of ration is best suited to sows and gilts during the latter part of the lactation period because of its lower fiber content.

**Ground limestone is added as insurance against the heavy drains of calcium during lactation. The additions of limestone may not be necessary, because the feeds furnish as much calcium as is usually recommended for lactation rations.

***See discussion of minerals.

Rations for Suckling Pigs

Pigs should be allowed access to a creep ration by the time they are two to three weeks old. The milk production of the sow declines after the third week and the pigs should have a maximum opportunity to consume feed.

During this period, palatability of the feed is exceedingly important. Numerous tests have shown that young pigs prefer whole corn (if the corn is not too hard) or coarsely cracked corn to finely ground grains. Pelleted feeds are more palatable to young pigs than finely ground gains and supplement. Rolled or hulled oats are very palatable to young pigs.

Several procedures may be followed in creep feeding pigs. A common practice is to feed shelled or cracked corn free choice with a protein supplement. Other cereal grains and their by-products may be mixed with the cracked corn and fed free choice or mixed with the protein supplement. They may also have access to the individual grains and proteins supplement.

Several examples of protein supplements for young pigs are shown in table 4. If the supplements are mixed with grain, there will usually not be much, if any, advantage from including more than 16% protein in the mixed creep ration while the pigs are nursing the sow. After weaning the protein level should be increased to 18% for maximum gains.

Numerous tests have shown that the addition of antibiotic supplements to creep rations may increase weaning weights considerably. It is not uncommon for antibiotic-fed pigs to weigh five pounds more at eight weeks of age than pigs fed good rations without antibiotics under similar conditions of management. For pigs nursing the sow, their grain and supplement should probably contain the equivalent of 20 grams of antibiotic per ton. Since there have been few studies made to test the optimum level of antibiotic in creep rations, the above level is a tentative recommendation.

Although good pasture furnishes many of the important nutrients, young pigs should not be expected to consume enough pasture to obtain appreciable amounts of these nutrients. It is best to include alfalfa or some other good source of vitamins in the supplement until the pigs weigh 50 to 60 pounds, even if they are on good pasture.

TABLE 4. Types of Protein Supplements for Pigs up to 50 or 75 Pounds.

	A	B	C	D	E	F	G	H	I
Approximate Protein Content*	39%	37%	41%	34%	38%	40%	40%	43%	40%
	weight - pounds								
Soybean meal	400	400	450	250	350	350	350	350	300
Tankage	300	---	300	200	300	300	300	200	200
Meat scraps	---	300	---	---	---	---	---	---	---
Fish meal	---	---	---	---	---	---	---	200	100
Alfalfa meal (sun cured)	300	300	---	250	250	250	250	250	---
Alfalfa meal (dehydrated)	---	---	250	---	---	---	---	---	200
Distillers' solubles (dried)	---	---	---	300	---	---	---	---	100
Whey (dried)	---	---	---	---	100	---	---	---	---
Skimmilk (dried)	---	---	---	---	---	100	---	---	---
Buttermilk (dried)	---	---	---	---	---	---	100	---	100
Ground limestone	---	---	---	15	---	---	---	---	---
Salt**	15	15	15	15	15	15	15	15	15
Total	1015	1015	1015	1030	1015	1015	1015	1015	1015

Ratios of above Supplements to Grain Mixtures to Give Mixed Rations Containing 16% Protein for Suckling Pigs.

1/2 cracked corn and 1/2 rolled or hulled oats; or 1/2 cracked corn, 1/4 rolled or hulled oats and 1/4 wheat middlings	86	85	87	83	85	86	86	88	86
Supplement	14	15	13	17	15	14	14	12	14

*See table 6 for ratios of supplements to corn if mixed rations are fed which contain 16% protein before weaning and 18% protein after weaning.

**See discussion of minerals.

Rations for Pigs After Weaning

The protein supplements shown in table 4 may be fed free choice with shelled corn to pigs after weaning. Some of these supplements may be more expensive than necessary for pigs weighing over 75 pounds. Many of the supplements shown in table 5 are generally less expensive and will usually produce just as satisfactory results for hogs beyond this weight. There is considerable overlapping in the supplements shown in tables 4 and 5. The first three supplements in each table are similar except for mineral content. Calcium and phosphorus levels of supplements A, B, and C shown in table 4 may be low for larger hogs, since the supplements will make up less of the total ration. The mineral additions to supplements shown in table 5 are made to compensate for lower protein intakes beyond 75 pounds.

Table 6 shows the ratios of protein supplements to corn needed to balance mixed rations. For example, approximately 30 pounds of a 40% supplement and 70 pounds of corn are needed to give a mixed ration containing 18% protein. Likewise, 26 pounds of a 34% supplement and 74 pounds of corn will give a mixed ration containing 15% protein.

For hogs on good pasture the alfalfa can be omitted from the supplements shown in table 5. The supplements can be fed free choice with shelled corn with some alterations. Since soybean meal is exceedingly palatable, it should probably not make up more than half of the supplement. A supplement of equal parts soybean meal and tankage is satisfactory for free choice feeding on pasture.

TABLE 5. Types of Protein Supplements that may be Self-fed to Growing-Fattening Swine in Dry Lot.

	A	B	C	D	E	F	G	H	I	J
Approximate Protein content	38%	36%	40%	40%	39%	40%	37%	38%	34%	38%
					weight - pounds					
Soybean meal	400	400	450	350	350	350	300	300	250	500
Cottonseed meal	---	---	---	100	---	---	---	100	---	---
Linseed meal	---	---	---	---	100	---	100	---	---	---
Peanut meal	---	---	---	---	---	100	---	---	---	---
Tankage	300	---	300	200	200	200	200	300	250	250
Meat scraps	---	300	---	---	---	---	---	---	---	---
Fish meal	---	---	---	100	100	100	100	---	---	---
Distillers' solubles (dried)	---	---	---	---	---	---	---	---	250	---
Alfalfa meal (dehydrated)	---	---	250	250	250	250	---	---	---	250
Alfalfa meal (sun cured)	300	300	---	---	---	---	300	300	250	---
Ground limestone	20	10	20	25	25	25	25	25	30	25
Steamed bone meal	10	---	5	10	10	10	10	---	10	15
Salt*	20	20	20	20	20	20	20	20	20	20
Total	1050	1030	1045	1055	1055	1055	1055	1045	1060	1060

*See discussion of minerals.

It should contain 2% salt and will require about 1% of added ground limestone.

As discussed earlier, the feeding of antibiotics to hogs in dry lot will increase gains and feed efficiency under many conditions of feeding (see discussion of antibiotics). A guide for feeding them is to add the equivalent of 10 grams of antibiotic to each ton of mixed feed for hogs up to 125 pounds and half this amount for hogs from 125 pounds to market weight. If the antibiotics are added to the protein supplement only, they should be added at the rate of 30 to 40 grams per ton. Antibiotic supplements also increase gains of hogs on pasture under many conditions, however, the benefit is usually less than for hogs in dry lot. It is difficult to predict whether their addition to rations for thrifty hogs on good pasture will always be economical in terms of extra gains and feed efficiency. In some cases, the extra gains per unit of feed will more than pay for the cost of the antibiotics added to rations fed to hogs on pasture.

Feeding Minerals Free Choice

Mineral mixtures can be fed free choice to swine instead of mixing them with protein supplements or mixed rations. Observation of the amounts of ground limestone and steamed bone meal needed to balance the rations and supplements discussed previously shows that no one mineral mixture is optimum for all of the various classes of swine fed different rations. Some of the rations need no added calcium or phosphorus, some need added phosphorus or calcium only, while other should be supplemented with both calcium and phosphorus.

TABLE 6. Ratio of Corn to Protein Supplements Needed to Obtain the Desired Level of Protein in a Ration.

Desired per cent of Protein in Ration		Percent Protein in Supplement 32	36	40	44	48	52
				weight - pounds			
18	corn*	60	65	70	73	76	78
	supp.	40	35	30	27	24	22
17	corn	64	69	73	76	78	80
	supp.	36	31	27	24	22	20
16	corn	68	73	76	79	81	83
	supp.	32	27	24	21	19	17
15	corn	72	76	79	82	84	85
	supp.	28	24	21	18	16	15
14	corn	77	80	83	85	86	87
	supp.	23	20	17	15	14	13
13	corn	81	84	86	87	89	90
	supp.	19	16	14	13	11	10
12	corn	85	87	89	90	91	92
	supp.	15	13	11	10	9	8

*The values apply to corn containing 8.5% protein.

It is not advisable to force pigs to eat ground limestone and steamed bone meal to receive sufficient salt. If mineral mixtures are fed free choice and no additional salt is offered, approximately 0.25% salt should be added to a mixed ration. If salt is added to the protein supplement only, approximately four times this amount (one percent) should be included.

Using the proportions of ground limestone, steamed bone meal and salt added to the supplements shown in table 5, mineral mixtures can be devised for feeding free choice. If 1% salt is included in the protein supplement (half the amount shown in table 5) or if it is fed free choice, a mineral mixture consisting of two parts ground limestone, one part steamed bone meal and one part salt will provide approximately correct proportions of calcium and phosphorus. Equal parts of ground limestone, steamed bone meal and salt or two parts of ground limestone, two parts of steamed bone meal and one part of salt are also satisfactory mineral mixtures for self feeding.

Feed Required in Terms of Gains

Since feed costs may account for as much as 80% of the total cost of producing swine for market, it is interesting to note how these costs are distributed over the growth period.

The data shown on table 7 are from those collected by Atkinson and Klein of the U.S. Department of Agriculture. These data represent twelve experiments with 813 hogs at several experiment stations. The data in the second column show that each hogs requires approximately 628 pounds of feed from a weight of 35 pounds to 200 pounds. The third and fourth columns show data which emphasize that, with each increase in size, pigs utilize their feed less efficiently. The data in the last column of the table show the net feed efficiency of pigs up to indicated weights. Even though young pigs utilize feed more efficiently than older hogs, the feed for the breeding herd assessed to them is greater per unit of body weight. As the pigs grow, the feed consumed by the breeding herd is distributed over more pounds of liveweight. At 200 pounds body weight, the pigs have utilized the total feed consumed by them and the breeding herd at a maximum rate of efficiency. At weights over 225 pounds the gains are less efficient because of the decreased feed utilization. Although the number of pigs raised per sow, the type of management, and the adequacy of the ration influence the outcome of experiments such as these, the data show that under average conditions the feed cost per pound of pork is lowest if hogs are marketed at 200 to 225 pounds.

TABLE 7. Feed Consumption and Efficiency of Gains of Pigs of Various Weights*

Live weight of pig	Cumulative feed per pig from 35 lbs.	Feed per 100 lb. gain during period	Cumulative Feed per 100 lb. gain from 35 lbs.	Cumulative Feed per 100 lb. gain, including feed for breeding herd
pounds	pounds	pounds	pounds	pounds
35 (wean. wt.)	---	---	---	766**
50	51	340	340	638
75	138	348	345	541
100	228	360	351	496
125	322	376	358	472
150	420	392	365	459
175	522	408	373	451
200	628	424	381	448
225	741	452	390	448
250	858	468	399	450
275	982	496	409	455
300	1113	524	420	460

*From data in U. S. D. A. Technical Bulletins 894 and 917.

**Includes feed consumed during the suckling period and the pig's share of the feed consumed by the breeding herd. The average total amount for a 35 pound pig at weaning is approximately 268 pounds.

TABLE 8. Approximate Content of Some Nutrients in Feeds. 1/

	Protein	Calcium	Phosphorus	Riboflavin	Niacin	Pantothenic Acid
	percent (pounds per 100 lbs.)			milligrams per pound		
Corn 2/	8-9	.01-.02	.25-.30	0.4-0.6	8-10	2.1-2.6
Oats	11-13	.08-.10	.35-.40	0.4-0.6	6-8	6.0-7.0
Barley	9-12	.04-.06	.35-.40	0.6-0.9	23-28	3.0-3.8
Grain sorghums	10-12	.02-.03	.30-.35	0.4-0.6	13-18	4.5-5.5
Rye	11-12	.08-.10	.30-.35	0.6-0.8	6.5-7.5	4.0-4.5
Wheat	13-15	.04-.06	.38-.42	0.4-0.6	25-30	5.5-6.5
Wheat middlings	15-17	.05-.10	.70-.90	0.7-1.0	40-45	9-11
Wheat bran	15-17	.10-.14	1.2-1.4	1.2-1.6	60-70	12-14
Soybean meal	41-44	.25-.30	.60-.70	1.3-2.0	15-20	6-7
Cottonseed meal	41-44	.20-.25	1.0-1.3	2.0-2.8	13-15	4.5-6.0
Linseed meal	33-36	.35-.40	.85-.90	1.3-2.0	15-20	7-8
Peanut meal	43-50	.10-.15	.50-.55	2.0-2.5	70-80	20-25
Tankage	60-62	6.0-6.5	3.0-3.5	1.0-1.5	18-22	1.0-1.5
Meat scraps	50-55	8.0-10.0	4.0-5.0	1.5-2.0	18-22	1.5-2.0
Meat and bone scraps	45-50	9.0-11.0	4.5-5.5	1.5-2.0	18-22	1.5-2.0
Fish meal	60-65	4.0-5.5	2.5-3.5	2.5-4.0	25-35	2-4
Alfalfa meal (dehydrated) 2/	15-20	1.3-1.6	.20-.25	6.0-7.5	10-18	10-18
Alfalfa meal (sun cured) 2/	13-17	1.2-1.4	.20-.30	5.5-6.5	10-16	8-12
Distillers' solubles (dried)	25-30	.30-.40	1.2-1.5	5-6	50-55	8-10
Brewers' yeast (dried)	45-50	.10-.15	1.0-1.5	15-20	220-230	50-60
Skimmilk (dried) 3/	34-36	1.2-1.4	.90-1.1	8-10	5.5-6.0	15-17
Buttermilk (condensed)	10-12	.40-.50	.20-.30	3-5	1.5-2.0	6-8
Buttermilk (dried)	31-33	1.3-1.4	.80-1.0	10-15	3-5	15-20
Whey (dried)	11-13	.80-.90	.70-.80	10-15	4-6	20-25

1/ There is considerable variation in values for different samples of the same feed. The ranges in values shown should represent most samples of a feed.

2/ Feeds other than yellow corn and green roughages contain very little carotene. Yellow corn usually contains from 1.2 to 1.8 milligram of carotene per pound. Dehydrated alfalfa and sun cured alfalfa usually contain from 40 to 60 milligrams and from 20 to 30 milligrams of carotene per pound, respectively.

3/ One gallon of liquid skimmilk is equivalent to 0.8 to 0.9 pound of dried skimmilk.