UNIVERSITY OF FLORIDA
IFAS EXTENSION

CIR849

Phosphorus Nutrition and Excretion by Dairy Animals [1]

B. Harris, Jr., D. Morse, H.H. Head and H.H. Van Horn[2]

Phosphorus plays a major role in the structure and function of living cells. It is an integral component of nucleic acids, nucleotides, phospholipids, and proteins, and a key component of many coenzymes. These compounds function in cellular division and growth, in the transport and metabolism of fats, and in the absorption and utilization of carbohydrates, fatty acids, and proteins.

Parturient paresis or milk fever can be a problem in dairy herds (Figure 1) when rations contain less than needed amounts of phosphorus. The phosphorus content of plasma and serum, however, decreases with a chronic or a prolonged deficiency even though the content in milk does not decrease. Phosphorus in bone is mobilized to some extent to maintain normal concentration in blood but at a slow rate since there is no direct mobilizing mechanism for phosphorus as there is for calcium. Since the two elements are combined in bone, the mobilization of calcium, as a result of parathyroid gland action, is accompanied by the incidental mobilization of phosphorus. Animals with chronic phosphorus deficiency sometimes become stiff in the joints and in severe cases, are characterized by fragile bones.

About 86% of the phosphorus in cattle is found in the skeleton and teeth and the remainder in soft tissues. Bone ash contains about 17% phosphorus. Blood serum varies in concentration from 3.0 to 8.0 mg of phosphorus/deciliter (dL) (Table 1).

Figure 1.

Phosphorus is absorbed in the small intestine as phosphate. Since phosphorus combines spontaneously with other elements, it is present in the body in the phosphate form (PO^{-3}). In the bones it occurs as calcium hydroxyapatite. All cells possess enzymes that can attach phosphates in ester or acid anhydride linkages to other molecules. Enzymes exist both inside and outside of the cells which remove phosphates from phosphate-containing molecules.

Phosphorus Requirements

Phosphorus requirements are highest during lactation, early growth, and for reproduction. High-producing cows need much more phosphorus

1. This document is CIR849, one of a series of the Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date February 1990. Reviewed June 2003. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
2. B. Harris, Jr., professor and extension dairy specialist; D. Morse, extension dairy specialist at North Dakota State University; H.H. Head, professor, and H.H. Van Horn, professor, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

than cows producing at average or low levels. Dry cows or cows that are not producing milk need less phosphorus than lactating cows due to the high content of phosphorus in milk.

Milk contains about 0.12% calcium and 0.095% phosphorus. A cow producing 100 pounds of milk daily would require 100 g (0.220 lb) of phosphorus and secrete 43 g (0.095 lb) of phosphorus in milk. Because of the high level of phosphorus in milk, a continuous supply is needed in the ration in order to allow high levels of milk production. The amounts of phosphorus required by dairy cattle, as set forth by the subcommittee on Dairy Cattle Nutrition of the National Research Council, are in Tables 2 and 8.

Rations for lactating dairy cattle are formulated to contain a given quantity or percent of phosphorus in order to meet the requirements for that specific nutrient. A lactating dairy cow producing 70 lbs of milk and consuming 47 lbs of dry matter (DM) daily and receiving a ration containing 0.4% phosphorus would receive the needed 82 grams of phosphorus as shown in Table 2 (47 x 0.004 = 0.188 lb x 453.6) = 85 grams.

Dry cows are those not producing milk after having completed a lactation. They are usually separated into two groups and noted as early and late dry cows. Late dry or springer cows are handled more carefully since they are in the last month of gestation when the fetus is growing at an accelerated rate. As shown in Table 3 , they need more phosphorus than the early dry cows.

Growing heifers weighing about 300 pounds need 12 grams of phosphorus daily (Table 2). Since heifers are fed to meet their energy and protein requirements, the total ration dry matter (DM) would need to contain an adequate amount of phosphorus in addition to other required nutrients. A heifer consuming 8.06 pounds of dry matter daily would need a total ration containing 0.33% phosphorus in the DM to provide the needed 12 grams. The phosphorus requirements for growing heifers gradually increases as the animals become more mature, with little to no increase beyond 900 pounds of body weight.

Phosphorus Sources and Availability

Ruminant animals obtain phosphorus from most feedstuffs fed to them. High quality forages tend to be low in phosphorus but concentrates are fairly good sources. Much of the phosphorus found in some cereal grains is bound to a chemical compound named phytate (Table 3). This source of phosphorus is poorly utilized by simple stomached animals (poultry, swine, etc.) but is readily available to ruminants. Ruminants have a true stomach or abomasum as you would find in monogastric animals.

In addition, ruminant animals have three other compartments (Figure 2). The rumen and reticulum make up a large fermentation vat where large numbers of bacteria and protozoa produce many enzymes that aid in digesting the consumed feed. The third compartment, the omasum, provides an absorption area even greater than the rumen.

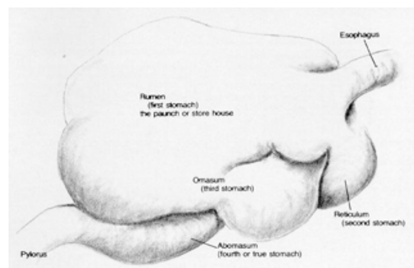

Figure 2.

Because of the unique digestive tract, ruminants utilize feedstuffs after a predigestion in the rumen-reticulum.

The forward location of the rumen gives the microbes priority to the soluble carbohydrates and proteins, as well as vitamins and minerals that are consumed. The more complex carbohydrates such as cellulose and hemicellulose that are in roughages are degraded at a much slower rate than the starches in corn. The microbes attach and degrade the complex feedstuffs into more simple compounds such as fatty acids and amino acids. Also, minerals and vitamins are released in the process and become available to the animal. Such is the case for phosphorus bound to phytate. Rumen microbes produce an enzyme called "phytase" that degrades the complex compound. As a result, phosphorus is released and available for absorption and utilization (Table 3). Recent studies by Clark et al. (1986) and Morse (1989) confirm research by Reid et al. (1947) with sheep which showed that a large percentage of the phosphorus bound to phytate was utilized. Studies by Morse, (1989) indicated that 99% to 100% of the phosphorus bound to phytate was hydrolyzed within a period of about 24 hours in rumen fluid (in vitro studies) and would be available for utilization (Table 4). While phytate phosphorus is well utilized, most dairy cattle rations still require further supplementation with inorganic sources of phosphorus such as defluorinated or dicalcium phosphate.

A number of feedstuffs are relatively high in phosphorus and, when used in combination or at levels of 10%-20%, tend to meet or exceed the requirements for phosphorus in the ration without further supplementation. Some of the more common ingredients high in phosphorus are in Table 5 .

Phosphorus Absorption

Phosphorus absorption occurs in the small intestine. The amount of phosphorus absorbed by the animal depends on the source of the phosphorus, the amount of intake, the calcium-phosphorus ratio, intestinal pH, disease and parasites, environment, the age of the animal, and dietary levels of calcium, iron, aluminum, manganese, potassium, magnesium and fat. Many of these factors become important when nutrients in diets are low or deficient. The regulation of phosphate absorption is mediated by vitamin D, (1,25-dihydroxyvitamin D_3). When the serum phosphate level is abnormally low, the formation of 1,25-dihydroxyvitamin D_3 in the renal tubule of the kidney is stimulated, causing enhanced phosphate absorption from the intestine. Ruminants recycle large amounts of phosphorus as inorganic phosphate in saliva, in which secretion appears to be regulated by the parathyroid hormone. Also, the parathyroid hormone along with vitamin D is involved in the mobilization of calcium and phosphate from bone.

Phosphorus and Milk Fever

An important concern dairymen have when reducing the amount of phosphorus in rations is the impact on milk fever incidence. Milk fever is a metabolic disorder that is associated with the level of phosphorus and calcium intake during the late dry period or very early lactation. It is caused by a sudden drop in the calcium content in the blood. Phosphorus appears to affect the cow's ability to mobilize calcium from bone and to absorb calcium efficiently from the intestine. Noticeable early symptoms are unsteadiness in walking, eyes dull and staring, pupils dilated, sleepy attitude and cold ears. As the case develops, the cow will be found lying down with her head displaced to one side or tucked into her flank. Complete paralysis, coma, and death occur unless an intravenous injection of a calcium solution is given.

During the dry period, it is desirable to not overfeed calcium and to maintain diet calcium and phosphorus near or slightly less than a 1.5 to 1.0 ratio. During lactation, problems are not usually encountered with a wider ratio as long as the level of phosphorus meets the animal's requirements.

Nutrient changes in a ration should be made gradually. This also is the case for phosphorus, especially when moving from a fairly high level to a lower level in the diet. The National Research Council recommends that the total ration dry matter for the late dry pregnant cow contain a minimum of 0.39% calcium, 0.24% phosphorus and 0.16% magnesium. The exact percent needed, however, would depend on the type and amount of ration being fed.

Since milk fever usually occurs at or near the time of calving and is more related to feeding during the late dry period, it is important that a good feeding program be developed for the dry cows. Just as sodium and potassium are associated with udder edema, calcium, phosphorus and sometimes magnesium are associated with the incidence of milk fever in a herd.

In 1964, Harris reported that borderline levels of phosphorus and higher than needed levels of calcium were associated with increased incidence of milk fever in many herds. The high level of calcium (Ca) fed was attributed to the high level of citrus pulp (1-3% Ca) included in the diets (normally 30-45% of diet). To combat the high incidence of milk fever, dietary phosphorus was increased. This simultaneously reduced the Ca:P ratio and reduced the incidence of milk fever. The level of phosphorus in dairy cattle rations tended to increase over the next few years since it was believed that phytate-bound phosphorus was unavailable to animals. As a result, discount values were established for certain feedstuffs. This resulted in a higher level of phosphorus in some rations. Research by Morse (1989) shows that these discount values are unnecessary.

Research to Reduce Excretion

A problem of great concern in South Florida is the concentration of phosphorus in Lake Okeechobee. This large lake (1900 square kilometers) ranging from 5 to 6 meters in depth, supplies drinking water to communities around the lake, serves as reserve water for Florida's southeast coast, and provides water to the Florida everglades. The lake also serves as a recreational facility and provides some of the best sports fishing in the United States. Nutrient rich runoff from farm lands enters the lake and significant phosphorus contamination originates from the dairy farms (>35,000 dairy cows) in the Taylor Creek-Nubbin Slough watershed. As concentration of phosphorus in the lake water increases, algae growth increases which may deplete the water of oxygen and disturb the ecosystem.

Graetz (1989) reported that waters originating from the northern end of the lake contain high concentration of phosphorus in the water. Since phosphorus has been identified as a troublesome nutrient to the ecosystems of Lake Okeechobee, research was needed to better define phosphorus intake versus phosphorus excretion.

Okeechobee Field Trial

During 1986-87, a study was conducted in the Okeechobee area to determine the effects of different levels of phosphorus intake on the excretion of phosphorus in feces. Five dairies, each milking 700 to 1550 cows were included in the study. Production and reproduction data were available for many of the cows sampled. One dairy had only first lactation cows, whereas other dairies had both first and greater lactation cows. Feed for these dairies was supplied by United Feed Cooperative (UFC) or Dairy Feeds, Inc. (DFI).

Concentrate portions of diets were formulated by feed mills for .42% phosphorus on two dairies, and .52% P on three dairies. Free choice mineral mix with minimum of 8.0% phosphorus was available for cows on one dairy where cows were fed .52% phosphorus. Feedstuffs used in the rations formulated included cottonseed hulls, malt sprout pellets, hominy, whole cottonseed, wheat middlings, soybean hulls, corn meal, cottonseed meal and rice bran.

Feed, fecal and bulk milk samples were collected monthly at each dairy. Fecal samples were retrieved per rectum from 20 randomly selected cows on each dairy. Also, samples of whole blood were taken from 10 to 15 randomly selected cows at each dairy. Concentration of phosphorus in the blood serum was an indication of phosphorus status of cows. The results are in Table 6 .

Phosphorus in the feces decreased when the concentration of phosphorus in the ration was decreased. Cows allowed access to free choice mineral had a greater concentration of phosphorus in the feces (MF3 vs MF4). The major dietary difference between cows at MF3 and MF4 was availability of free choice mineral at MF3.

Intake and Excretion

The Okeechobee field trial indicated some relationship exists between phosphorus intake and phosphorus excretion. Lomba et al. (1969) summarized 14 experiments in mature, lactating, non-pregnant dairy cows producing 24 to 44 pounds of milk daily and found no relationship between dietary phosphorus intake and excretion. Two additional experiments were conducted at the University of Florida to evaluate the effects of phosphorus intake on amount and route of phosphorus excretion and on level of phosphorus in diet on voluntary feed intake and milk production.

Twelve Holstein cows were used in a 13-week continuous trial in the first experiment. Cows were assigned randomly to one of three dietary concentrations of phosphorus: .30%, .41% or .56% of diet dry matter (DM). These diets are identified as low (L), medium (M), and high (H) in concentration of phosphorus and represent 79% (deficient), 108% (adequate), and 147% (excess) of recommended nutrient requirements for a 1300-lb dairy cow producing between 46 lb and 70 lb of 4% fat milk daily (NRC, 1988).

The study showed that the concentration of phosphorus in feces was altered by the concentration of phosphorus in the diet but had little or no effect on amount of phosphorus excreted in milk or urine (Table 7). Increasing the intake of phosphorus from 82 g/d to 112 g/d resulted in a 48.6% increase in the excretion of phosphorus in feces. Reducing the intake of phosphorus from 82 g/d to 60 g/d resulted in a 22.7% decrease in the excretion of phosphorus in feces.

Since voluntary feed intake was restricted to 44 lbs of DM/d for these cows, a second trial was conducted using 24 Holstein cows to study the effect of different levels of dietary phosphorus and Ca on voluntary feed intake and milk production and composition. Levels of phosphorus used were .33%, .43%, and .54% of ration DM. Again, these levels represented less, adequate, or high level of phosphorus in diet of high-producing cows relative to NRC requirement (0.41% of diet DM as phosphorus; NRC, 1988). Concentrations of Ca were .60% and .97% of diet DM representing 100% and 162% of currently recommended concentrations of Ca (NRC, 1988).

Concentrations of dietary phosphorus (.33%, .43%, and .54% of DM) did not affect voluntary intake of feed or production of milk. Although milk production tended to be higher on low phosphorus, the results showed no difference in DM intake for ratios of Ca:P between 1.1:1 and 2.9:1. There was a trend for DM intake to increase with decreased concentration of phosphorus. Production of 3.5% FCM was 4.8% greater in cows fed a .60% calcium diet when compared to cows fed a .97% Ca diet.

Formulating Rations

Consideration should be given to the total ration when formulating premixes, mineral mixtures or the concentrate portion of the ration. A balanced ration is one that provides the nutrients in such proportions and amounts that will properly nourish a given animal for 24 hours (Morrison, 1956). In addition, consideration must be given to the amount of dry matter the animal is able to or will consume during the 24-hour period. In formulating rations, a number of components are usually considered such as protein, energy, fiber, minerals and vitamins. In this discussion, we are primarily interested in the level of phosphorus in rations and how it relates to calcium, magnesium, protein and energy.

Some feedstuffs are better sources of minerals than others (Table 3). While textbook values are commonly used for many feedstuffs, an analysis of the forage is preferred since they vary considerably in composition. This is especially true for legume forages which are relatively high in minerals.

In addition to formulating balanced rations for dairy cattle, attention must be given to meeting the nutrient requirements of the cow at the lowest possible cost. Computer programs are available to assist in the formulation of optimum diets at minimum costs. Table 8 contains the requirements for calcium and phosphorus for lactating cows (NRC, 1988).

A few examples of total mixed rations are presented to show the level of calcium and phosphorus needed by dairy cattle as outlined in Table 8.

Ration 1 (Table 9) is a high energy ration that contains 0.79% calcium and 0.48% phosphorus on a dry basis. Since ration 2 (Table 10) contains a lower energy roughage source, less calcium and phosphorus is needed as a percent of the dry matter since dry matter intakes are greater when cows receive cottonseed hull rations.

Ration 3 (Table 11) contains rice bran which is an excellent source of phosphorus. Note that the mineral supplement contains no phosphorus. Ration 4 (Table 12) contains some green chop and bermuda hay in addition to a purchased grain mix that contains cottonseed hulls.

Many Florida dairymen purchase a premix or concentrate to blend with the forages available on the farm. Since forages tend to be low in phosphorus, a greater percent of phosphorus is needed in the concentrate. Such is the case with rations 1, 2, 3 and 4 where both the forage type and amount varies in the ration and the percent in the total ration dry matter varies from 0.43 to 0.49%.

Summary

Phosphorus is an important mineral element which is key to energy metabolism and is an essential component of buffer systems in blood and other body fluids.

Phosphorus requirements of dairy cows vary according to level of milk production, body size and stage of gestation. As an example, a 1400-lb dairy cow producing 85 lbs of 3.5% milk needs about 88 g (.20 lbs) of phosphorus daily as compared to 59 g (.13 lbs) for a similar cow producing 50 lbs of milk (NRC, 1988).

Phosphorus bound to phytate accounts for a large amount of the phosphorus present in feedstuffs commonly fed to dairy cattle. The results of our studies revealed that 99% to 100% of the phosphorus bound to phytate would be hydrolyzed in the digestive tract and be available for utilization. There was no evidence to indicate or suggest any discounting value of phosphorus bound to phytate when formulating diets for lactating dairy cows.

Phosphorus is excreted primarily through feces and milk. The level of phosphorus in milk appears to remain constant with different levels of phosphorus in the ration. Once cows attain a balance of phosphorus for body functions and needs, the amount of phosphorus excreted in the feces will increase.

Research indicates that the NRC (1988) recommended level of phosphorus (0.4 to 0.43% of ration dry matter) for lactating dairy cows is enough for optimum performance. Feeding more increases the amount excreted in the feces. Restricting dietary intake of phosphorus to NRC allowances will help to reduce the amount of phosphorus excreted in the feces while providing adequate phosphorus for other body functions.

Selected References

1. Clark, W. D., Jr., J. E. Wohlt, R.L. Gilbreath, and P. K Zajac 1986. "Phytate phosphorus intake and disappearance in the gastrointestinal tract of high producing dairy cows." *J. Dairy Sci* . 69:3151.

2. Graetz, D.A. 1989. "Phosphorus levels in soils of selected Lake Okeechobee watershed dairies." Proc. Florida Dairy Production Conf., Gainesville, Fl. pp.113-118.

3. Harris, B. Jr. 1964. "Minerals in dairy rations." Florida Dairy Extension Newsletter.

4. Lomba, F.,R. Paguay, V. Bienfet, and A. Lousse. 1969. "Statistical research on the fats of dietary rnineral elements in dry and lactating cows." III. Phosphorus. *J. Agric. Sci* . 73:215

5. Morrison, F. B. 1956. "Feeds and feeding". 22nd Ed. The Morrison Publishing Co., Clinton, Iowa.

6. Morse, D. 1989. "Studies of modification of phosphorus concentration in diets, hydrolysis of phytate bound phosphorus, and excretion of phosphorus by dairy cows." Ph.D. Dissertation

7. National Research Council. 1988. "Nutrient requirements of dairy cattle," 6th rev. ed. Washington, D.C.: National Academy Press.

8. Reid, R.L., M. C. Franklin, and E. G. Hallsworth. 1947. "The utilization of phytate phosphorus by sheep." *Aust. Vet. J* . 23:136.

Table 1.

Table 1. Normal levels of selected minerals in blood serum.	
Component	Normal Values (mg/dL)[1]
Calcium	9-10.6
Magnesium	1-3
Phosphorus	3-8
Potassium	14-20
Sodium	310-340
1dL=0.1 liter or 100 milliliters.	

Table 2.

Table 2. Daily nutrient requirements for growing, dry, and lactating ddairy cattle (3.5% fat, 1400 lb body wt.)

Live wt (lb)	Gain (lb)	Milk Yield (lb)	Minerals		DMI	TDN	CP
			Ca (gms)	Phos (gms)[1]	---------------------------lbs-------------------------		
90	0.6	-	6.8	4.1	1	1.32	0.24
150	1.7	-	15.4	7.7	4	3.92	0.77
300	1.7	-	19.5	11.4	8	5.56	1.29
700	1.7	-	24.9	18.6	16	10.27	1.94
900	1.7	-	28.6	20.9	21	12.75	2.52
1400	-	(Dry)	25.9	18.2	-	12.75	2.52
1400	-	(Late Dry)	41.8	25.4	-	12.90	2.20
1400	-	35	73.5	46.7	35	21.00	4.20
1400	-	70	121.1	75.3	47	30.83	6.90
1400	-	100	162.0	100.0	58	39.90	9.27

1453.6 grams = 1 pound; DMI =dry matter intake; TDN =total digestible nutrients; CP =crude protein.

Table 3.

Table 3. Concentration of total phosphorus and phosphorus bound to phytate in selected feedstuffs.

Feedstuff	Number Samples	Total Phos.	Phytate	Phytate Phos.
		------------------------------ppm[1]------------------------		%
Cottonseed meal	2	12220	8480	69.4
Distillers, dried	2	8990	2880	32.0
Corn meal	3	2980	1900	63.8
Hominy feed	3	6380	4680	73.4
Peanut meal	2	6650	3800	57.1
Rice bran	2	15780	12560	79.6
Soybean meal	2	7320	5020	68.6
Wheat midds	3	13400	10480	78.2

1ppm = parts per million

Table 4.

Table 4. Percent disappearance of P bound to phytate with time in rumen fluid.

Ingredient	Hours of Incubation in Rumen Fluid[1]			
	2	6	12	24
Wheat midds	84.5	94.9	98.1	99.8
Rice bran	85.3	82.6	98.1	99.8
Hominy feed	52.5	90.0	99.4	99.8
Soybean meal	31.3	50.2	99.9	100
Dried distillers grain	71.3	95.4	98.7	99.3
Cottonseed meal	48.7	57.0	71.5	99.9

1Morse, 1989.

Table 5.

Table 5. Feedstuffs commonly used in Dairy Cattle Rations (as fed).

Feedstuff	CP[1] %)	TDN[1] (%)	Calcium (%)	Phosphorus (%)
Canola meal	37	64	.68	1.10
Corn gluten feed	21	74	.30	.76
Corn gluten meal	60	82	.02	.62
Cottonseed, whole	21	90	.14	.68
Cottonseed meal	41	70	.20	.90
Malt sprouts	20	65	.20	.70
Peanut meal	50	74	.20	.60
Rice bran	12	60	.60	1.40
Rice mill feed	6	32	.08	1.30
Soybean meal	44	78	.20	.60
Wheat midds	16	76	.10	.90

1CP = crude protein; TDN = total digestible nutrients

Table 6.

Table 6. Concentration of phosphorus found in the concentrate, feces and blood serum of dairy cows.

	Phosphorus Concentration		
	Total diet (% of DM)	feces (ppm)	serum (mg/dL)
DLD 1[a]	0.57	7317	5.98
DLD 2 (Low)	0.47	6344	6.33
MF 1 (Low)	0.51	6942	5.89
MF 3 (free choice)	0.71	9533	6.28
MF 4	0.71	8931	6.01

aDLD= Dry Lake Dairies Barns 1 and 2. MF- McArthur Farms Barns 1,3, and 4.

Table 7.

Table 7. Least squares means for three levels of phosphorus on excretion of phosphorus in feces, milk and urine.

Measurement	Low (.30 %; 60 g/d)	Medium (.41 %; 82 g/d)	High (.56 %; 112 g/d)
Feces (g/d)	40.30	45.10	62.94
Milk (g/d)	18.40	20.40	22.00
Urine (g/d)	.66	1.26	3.36

Table 8.

Table 8. Calcium and phosphorus requirements of small cows producing 4.5% milk fat and larger cows producing 3.5 % milk fat.

Wt.	Milk	Ca.	Phos.	Wt.	Milk	Ca.	Phos.
---lb---------------------------------				--lb--------------------------------			
1000	35	.164	.103	1000	75	.304	.187
1400	35	.162	.103	1400	75	.282	.175
1000	50	.216	.134	1400	80	.297	.184
1400	50	.207	.130	1400	85	.312	.193
1000	65	.269	.166	1400	90	.327	.202
1400	65	.252	.157	1400	100	.357	.220

Table 9.

Table 9. Ration No. 1

	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs-----------------------------------					
Corn Silage	45.00	13.50	1.13	9.00	0.04	0.02	4.05
Alfalfa Hay	6.00	5.34	1.08	3.00	0.05	0.01	1.68
Corn Meal	8.00	7.20	0.69	6.40	.00	0.02	0.24

Table 9.

Whole Cottonseed	5.00	4.50	1.05	4.50	0.01	0.03	0.85
Wheat Midds	3.00	2.67	0.48	2.28	.00	0.03	0.18
Soybean Hulls	3.00	2.67	0.36	1.95	0.01	.00	0.36
Distillers grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Soybean meal (48 %)	4.20	3.78	2.02	3.19	0.01	0.03	0.08
Mineral	1.40	1.32	0.00	0.00	0.02	0.05	0.00
Total Intake	78.60	43.68	7.58	32.72	0.34	0.21	7.80
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			17.35	74.92	0.79	0.48	17.87

Table 10.

Table 10. Ration No. 2

	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs---					
Cottonseed hulls	12.00	10.00	0.48	4.80	0.02	0.01	5.16
Alfalfa Hay	8.00	7.12	1.44	4.00	0.06	0.02	2.24
Corn Meal	11.00	9.90	0.95	8.80	.00	0.03	0.33
Whole Cottonseed	5.00	4.50	1.05	4.50	0.01	0.03	0.85
Wheat Midds	4.00	3.56	0.64	3.04	.00	0.04	0.24
Soybean Hulls	3.00	2.67	0.36	1.95	0.01	.00	0.36
Distillers grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Soybean meal (48 %)	4.00	3.60	2.92	3.04	0.01	0.02	0.08
Mineral	1.50	1.41	0.00	0.00	0.24	0.04	0.00
Total Intake	51.50	46.26	7.62	32.53	0.35	0.21	9.62
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			16.46	70.32	0.76	0.45	20.80

Table 11.

Table 11. Ration No. 3							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs---					
Cottoonseed Hulls	13.00	11.70	0.52	5.20	0.02	0.01	5.59
Bermuda Hay	6.00	5.34	1.02	2.28	0.02	0.01	1.92
Hominy Feed	15.00	13.50	1.50	12.30	0.01	0.08	0.45
Whole Cottonseed	5.50	4.95	1.16	4.95	0.01	0.04	0.94
Rice Bran	4.00	3.56	0.48	2.40	.00	0.06	0.40
Distillers Grains	3.00	2.70	0.78	2.40	.00	0.01	0.36
Peanut Meal	4.20	3.78	2.10	3.19	0.01	0.03	0.17
Mineral	1.60	1.50	0.00	0.00	0.28	0.00	0.00
Total Intake	52.30	47.03	7.56	32.72	0.34	0.23	9.82
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			16.06	69.57	0.72	0.49	20.88

Table 12.

Table 12. Ration No. 4							
	lbs.	Dry Matter	Crude Protein	TDN	CA	PHOS	Crude Fiber
		---lbs---					
Bermuda Hay	7.00	6.16	0.49	2.80	0.02	0.01	2.24
CSH Grain Mix	41.00	36.90	6.56	26.65	0.31	0.19	6.15
Green Chop	30.00	6.00	0.45	3.60	0.02	0.01	1.80
Total Intake	78.00	49.06	7.50	33.05	0.35	0.21	10.19
Requirements (70 # Milk)			7.50	32.30	0.32	0.20	-
Ration Percent Dry Matter			15.29	67.37	0.71	0.43	20.77