

Phosphorus Requirements of Different Species, Phytase Feeding, and Ration Formulation

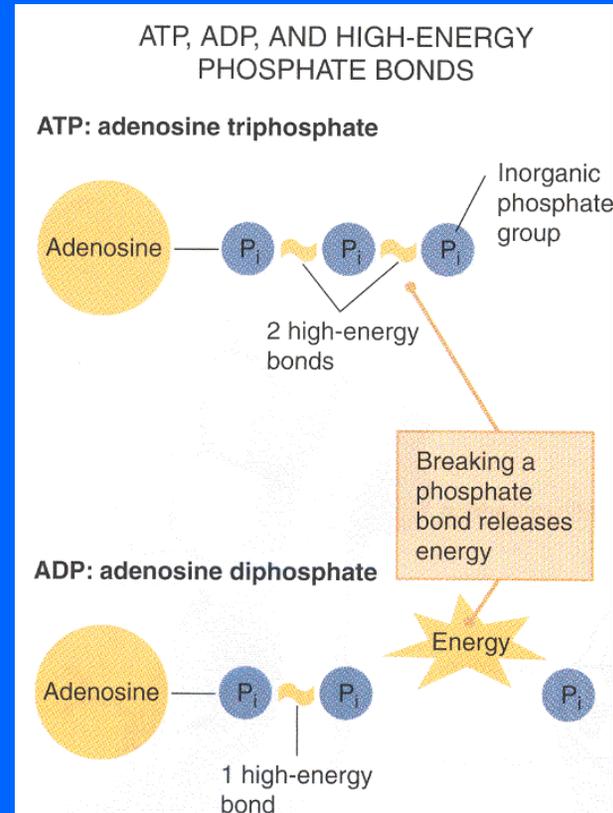
By Ron Kincaid - WSU



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Capturing energy from our food is done by forming high-energy P bonds.

- Synthesis of proteins and other compounds in the body require energy obtained from food. Much of this energy is captured as ATP.



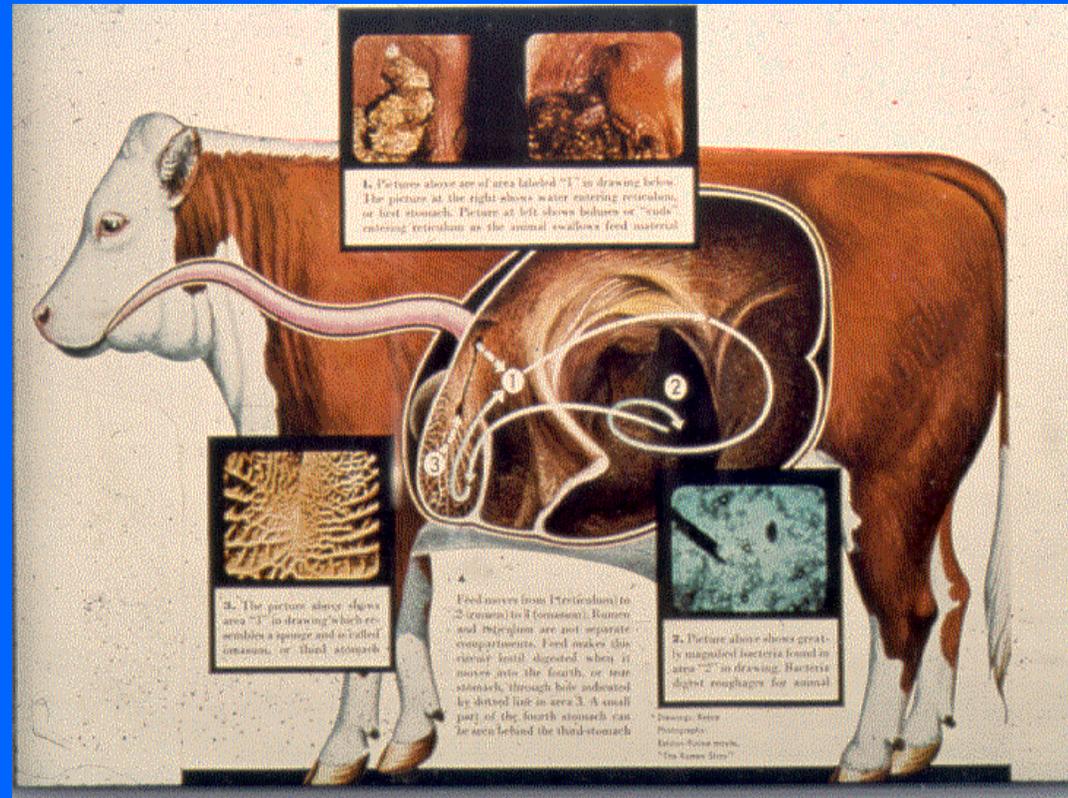
Most body phosphorus is present in our bones

- Distribution of P in the body:
- 85% in bones
- 14% in soft tissues and muscles
- 1% in blood

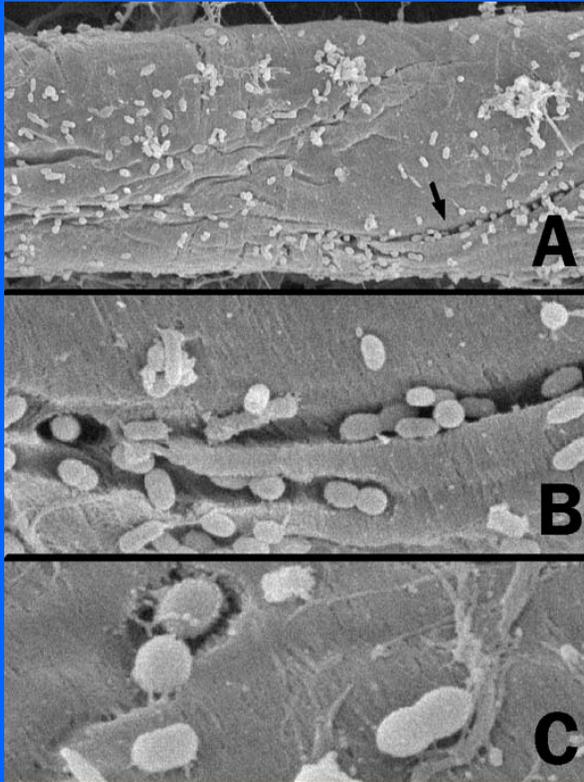


Cattle need P to support the micro-organisms that ferment feeds in the rumen.

- Pregastric digestion of cellulose requires bacteria that need P.
- Cattle recycle P into the rumen via saliva.
- Total P of microbes is 2 to 6%, DM.



Magnifications of Cocci Attached to Fiber



- When ruminal microbes enter the small intestine, their DNA and RNA are degraded to release P for absorption.
- ~2/3 of P inevitably lost in feces of ruminants occurs in voided microbes.



Consequences of Inadequate P Intake by Animals

- Osteomalacia (deficient calcification of bones; rickets)
- Anorexia (lack of appetite)
- Reduced performance (growth, milk yield or egg production)
- Pica
- Lethargy, muscle weakness, seizures, erythrocyte deformity, hemolysis.



P Deficiency

- Joint surface of a P-deficient cow.
- Note the severe erosion of the surface.



Pica in Phosphorus Deficient Cow



Pica is an appetite for objects not fit as food.

Cattle develop an appetite for bones, which often contain *Clostridium botulism*.

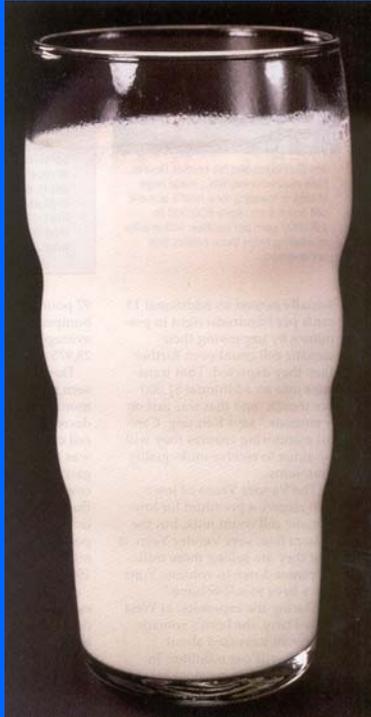


Variation in P requirements as a function of life cycle

- Some P is lost from the body (endogenous loss) during metabolism and must be replaced.
- Additional P is needed for growth, pregnancy, lactation, and egg production.
- **Accordingly, P requirements are highest for animals that are most productive.**



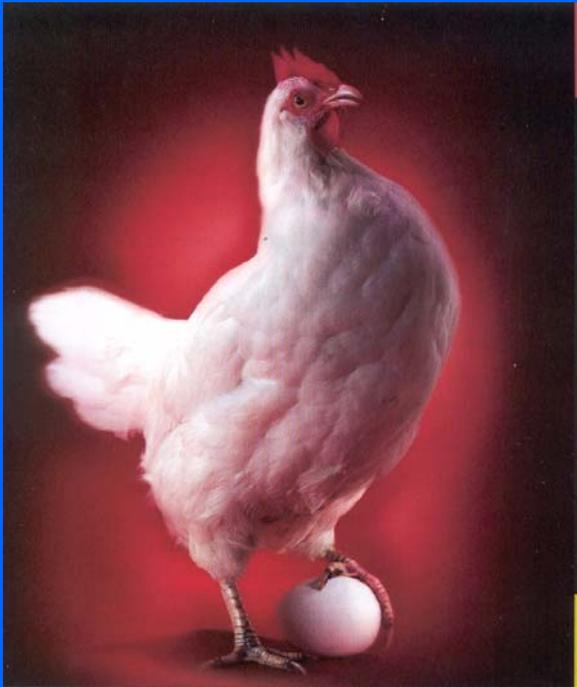
Phosphorus Needs for Milk Production



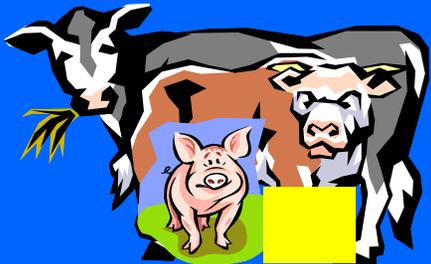
- Milk contains ~0.09% P, thus a gallon of milk contains ~3.43 g of P.
- A glass (pint) of milk contains ~0.43 g of P.
- If producing 100 lb of milk/day, a cow secretes 41 g of P/d.



Phosphorus Needs for Egg Production



- An egg contains ~86 milligrams of P.
- An egg (shell-less) weighs 50 g, hence contains 0.17% P



Phosphorus Requirements of Dairy Cattle

Class	Dietary P needs, DM	Comments
Replacement heifers	0.27%	550 lb, 2 lb ADG
Dry cows	0.23%	
Lactating cows	0.38%	120 lb milk, 90 DIM



Phosphorus Requirements of Beef Cattle

Class	Dietary P Needs	Comments
Lactation	0.16%	90 DIM, 9 lb milk
Dry, pregnant, 1100 lb	0.19%	Last 3 rd of pregn
Pregnant heifers, 900 lb	0.23%	Last 3 rd of pregn
Steers, 550 lb, 1.5 lb ADG	0.24%	
Steers, 1000 lb, 3.0 ADG	0.20%	



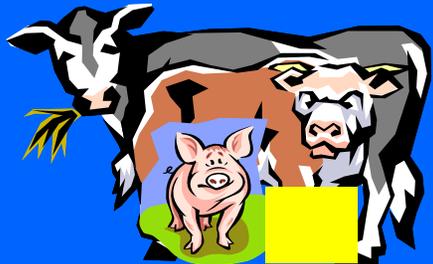
Phosphorus Requirements of Sheep

Class	Dietary P needs	Comments
Ewes, maintenance, 154 lb	0.25%	
Ewes, pregnant	0.20%	6 wk prelambing
Ewes, lactating	0.34%	
Replacement lambs, 66 lb	0.25%	



Phosphorus Requirements of Horses

Class	Dietary P Needs	Comments
Maintenance	0.17%	Mature horses
Yearling	0.24%	12 mo, mod growth
Light work	0.22%	Pleasure
Lactating mares	0.34%	Foaling until 3 mo



Phosphorus Requirements of Pigs

Class	Dietary P Needs
Sows, lactating or pregnant	0.6% total P 0.35% available P
Growing pigs, 22-44 lb	0.6% total P 0.32% available P
Growing pigs, 110-242 lb	0.4% total P 0.15% available P



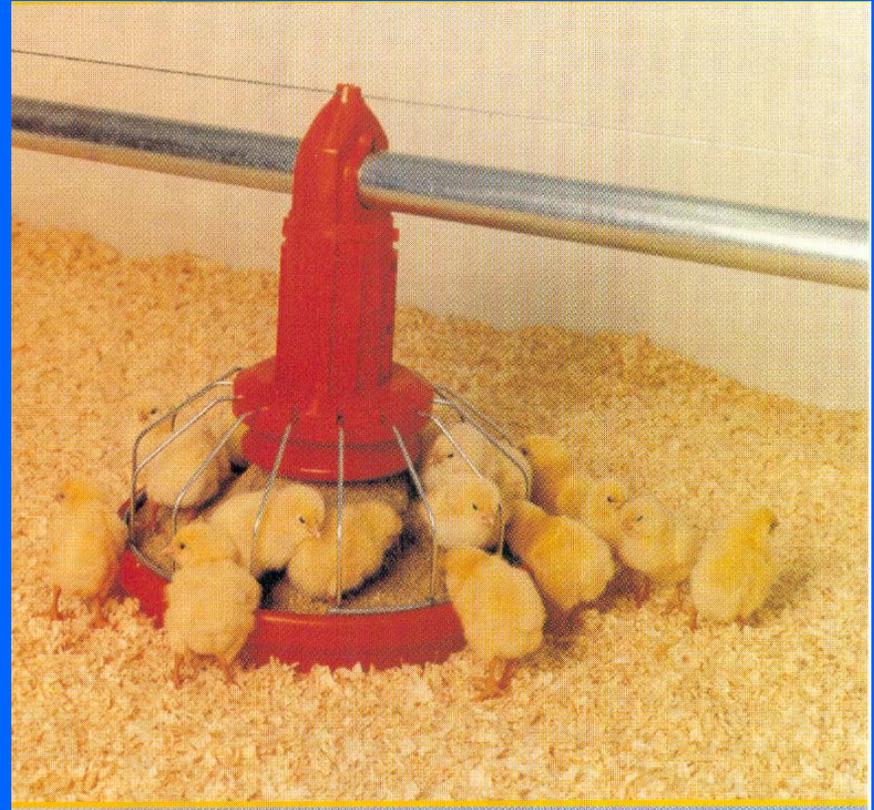
Phosphorus Requirements of Layers

Class	Dietary P Needs
Leghorn laying hens	0.25% nonphytate P
Leghorn chicks, 0-6 wk	0.40% nonphytate P
Leghorn chicks, 6-12 wk	0.35% nonphytate P
Leghorn chicks, 12-18 wk	0.30% nonphytate P
Leghorn chicks, 18 wk-lay	0.32% nonphytate P



Phosphorus Requirements of Fryers (Broilers)

- Faster growth rate, hence higher P requirements.
- Broilers, 0-3 wk, need 0.45% nonphytate P.
- Broilers, 3-6 wk need 0.35% nonphytate P.
- Broilers, 6-8 wk, need 0.30% nonphytate P.

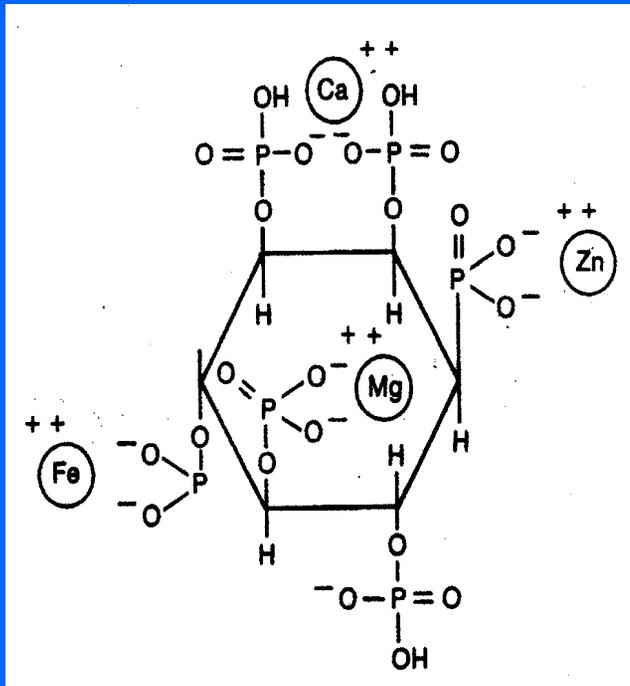


Available P or Nonphytate P Requirements for Pigs and Chicks

- Over 60% of the P in grains (corn, barley, wheat, etc.) cannot be used by pigs and chicks because they cannot “free” the P.



Phytate, the chemical form of much of the phosphorus in grains

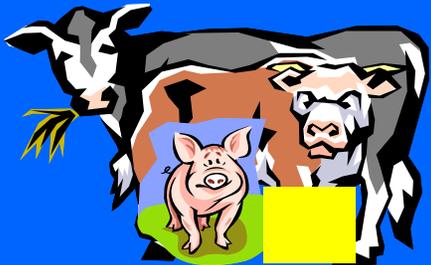


- Animals do not make the enzyme needed to hydrolyze the P from phytate. Only bacteria make the needed phytases.



Exogenous Phytases

- Phytases are commercially available to add to diets.
- They “free” about 25% of the dietary P needs for chicks and pigs.
- Accordingly, they reduce the need for added inorganic P to recover their costs.
- Phytases reduce P excretion by >25%.



Phosphorus Availability from Various Sources

- P in grains is poorly available for absorption by nonruminants, unless phytases added.
- Most inorganic sources of P have higher absorption coefficients than organic sources.



Phosphorus Concentrations and Availabilities in Feeds

		Poultry	Cattle
Source	% P	---% P Availability---	
Ca phosphate	19.0	100	75
Corn	0.28	35	70
Soy meal, 44	0.65	25	70
Alfalfa	0.32	NA	64



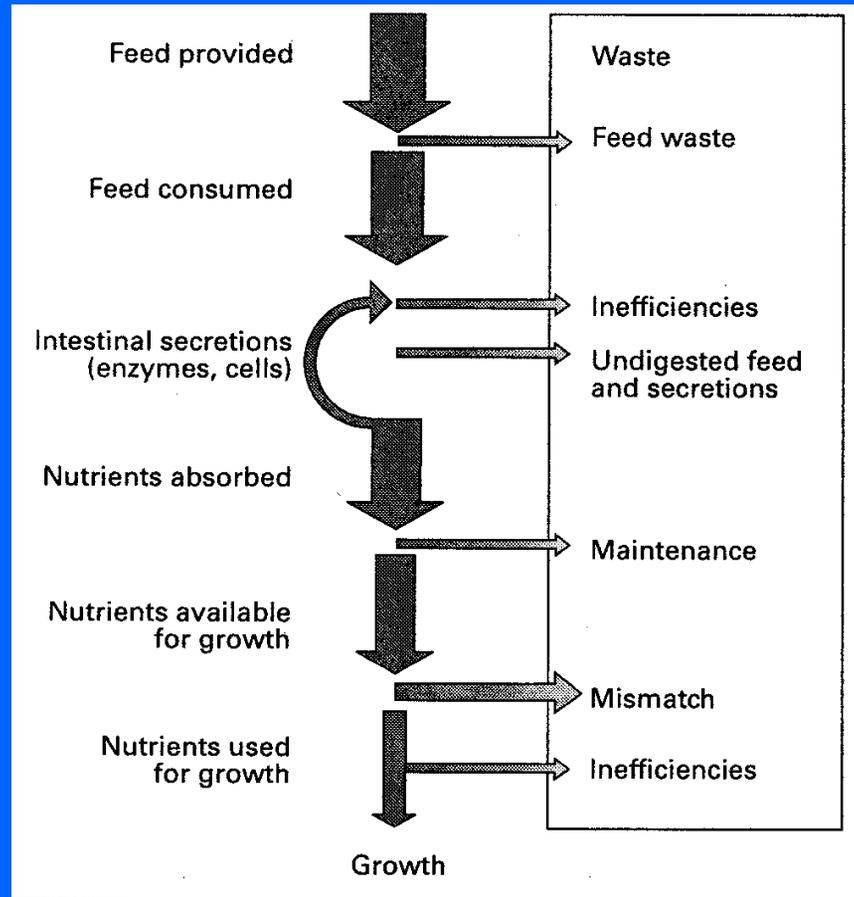
Phosphorus Excretion by Livestock

- Often includes waste feed and bedding
- Several ways to express nutrient excretion: e.g., total excretion or concentration
- Pounds/animal/year
- Pounds during lifespan of animal
- **Concentration in lagoon or manure pile**
- **Concentration (as is or DM basis)**



Reasons for P Loss by Animals

- Unused P results from waste feed, undigested P, overfeeding P, body metabolism, hair/feathers, and bedding.

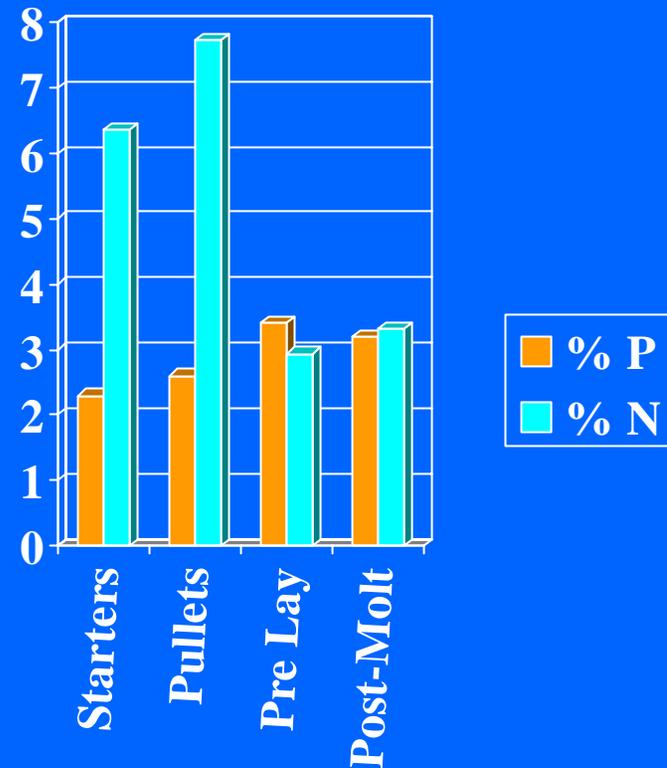


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*Figure from www.lpes.org/lessons/

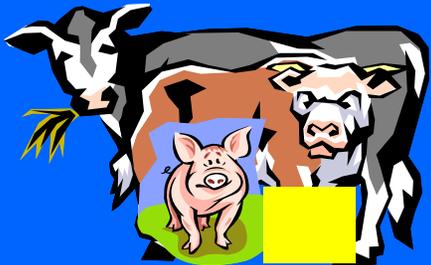
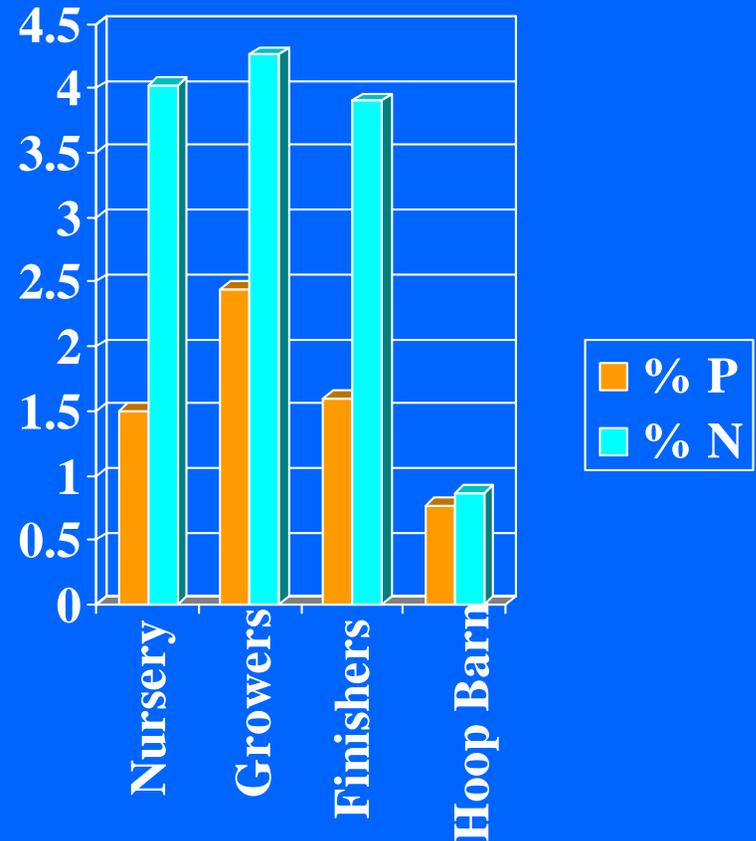
Phosphorus and Nitrogen (% DM) in Poultry Litter Obtained in WA

- Poultry litter includes feces (urine voided with the feces), waste feed, feathers, and any bedding material.

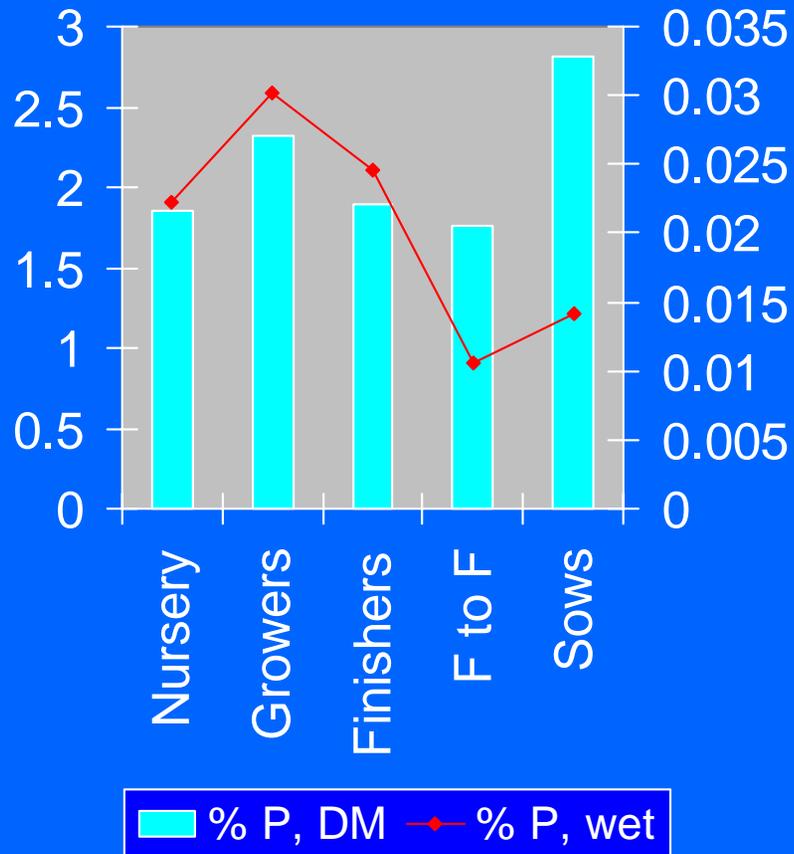


P and N (% DM) in Swine Manure

- A pig excretes ~ 3.3 lb of P from farrow to finish.
- The %P and N are lower in the Hoop Barn manure because it includes bedding.



Phosphorus in Swine Lagoons



- Data can be expressed on DM basis or an as-is (wet) basis.



- A dairy cow excretes 40 to 69 lb of P/year.
- P excretion is a function of feed intake and % P in diet.
- The manure contains 0.5-1.5% P, depending upon diet and how the manure is collected.

Dairy Cattle



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- Because beef cows have lower feed intakes and are fed more roughages, both % P in manure and total P excretion are less than dairy cows.

Beef Cattle



Feedlot Cattle



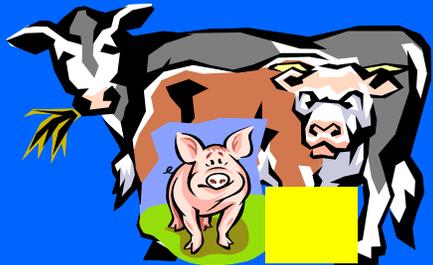
- Calf excretes 7-10 lb of P during a 120 day finishing period. Feedlot cattle are often overfed P because most of their feed ingredients tend to be high in P relative to requirement.



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Ration Formulation

- Rations are formulated to first meet energy and protein needs. Energy and protein are the most expensive.
- **Other ingredients added to meet requirements.**
- Phytase easy to incorporate into rations because phytases replace some inorganic P supplements.

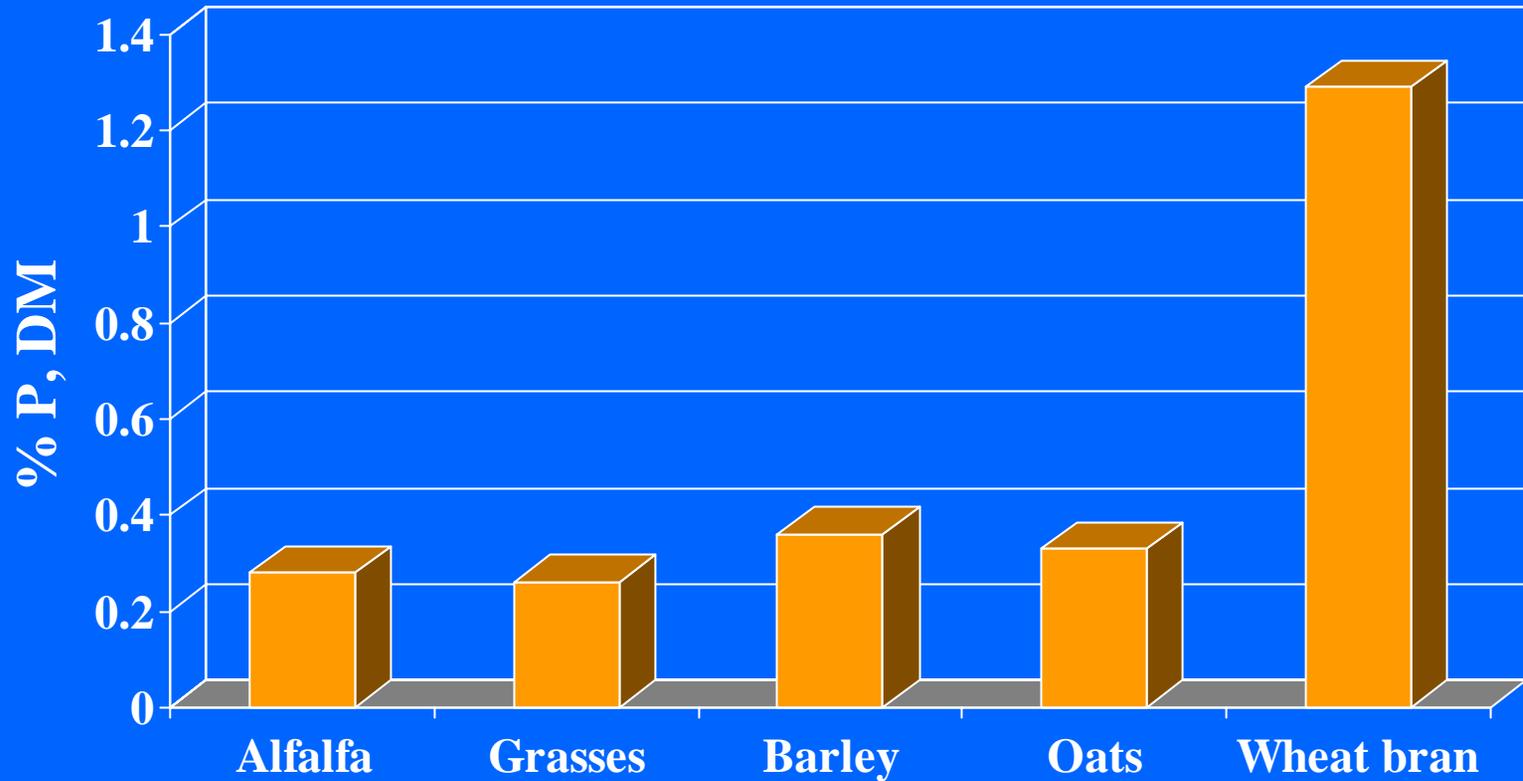


Reasons that Phosphorus is Often Overfed

- Many protein and byproduct feeds contain fairly high concentrations of P.
- **These ingredients are fed to meet protein and energy requirements of the animals.**
- The challenge is to formulate least-cost diets that meet other requirements but not exceed the P requirement.



% P In Some Horse Feeds

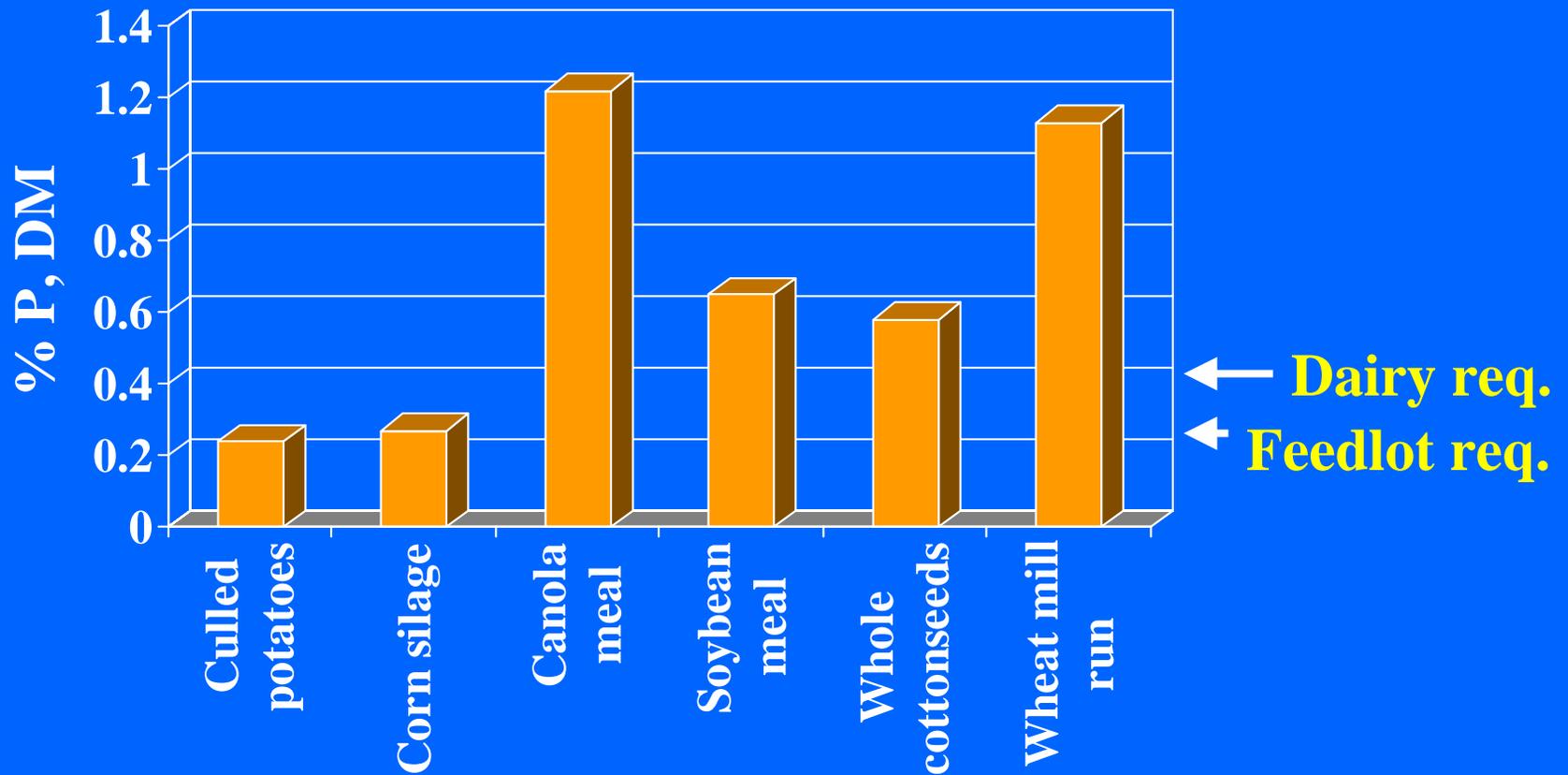


Maintenance is 0.17%

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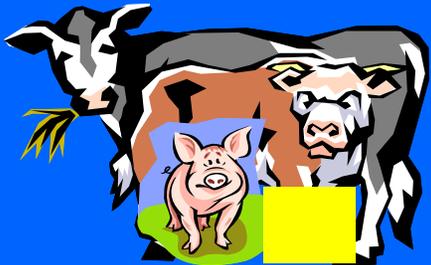


% P In Some Cattle Feeds



Ways to Reduce Phosphorus Content of Diets and Phosphorus Losses

- 1. Formulate for the minimum P requirement.
- Differences in P digestibility among feeds have already been considered by the NRC Nutrient Requirement Committees.



Ways to Reduce Phosphorus Content of Diets and Phosphorus Losses

- 2. Phase Feed Animals, i.e., group according to age or production status.
- Nutrient requirements change as animal grows, enters late gestation, or begins lactation (or lay).

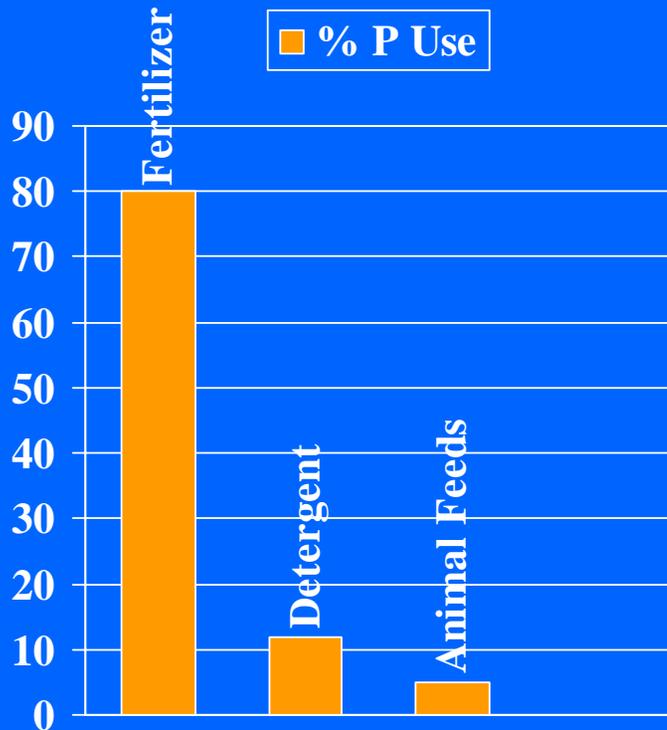


Ways to Reduce Phosphorus Content of Diets

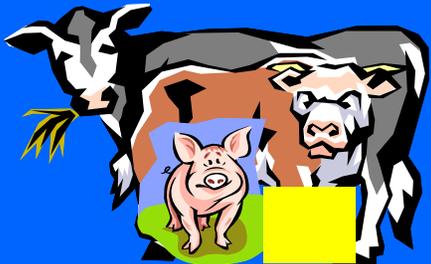
- 3. Utilize phytases in diets of nonruminants.
- Exogenous phytases reduce P excretion by > 25%.



Conclusion



- Only ~5% of worldwide P use is for animal feeds.
- However, care is needed to avoid contaminating water with P from livestock operations.



Conclusion



- Reductions can be made in P intake & excretion of livestock.
- Perhaps a future focus will be recovery of P from manure solids and slurry.

