Feeding Barley to Swine & Poultry

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Types of Barley

Barley cultivars are available for fall planting or for spring planting. Fall-planted (or winter barleys) are seeded in areas where the winters are relatively mild. Spring-seeded barleys are planted in areas such as the Northern Great Plains of the United States where winters are relatively harsh. Few, if any, specimens of fall-seeded cultivars planted in the fall in North Dakota would be expected to survive northern winters because of limited plant hardiness to cold weather.

Within the cultivars available for planting in either the spring or the fall planting seasons, two-row and six-row types may be seeded. Two-row varieties are adapted to drier climates while six-rowed cultivars are planted where moisture is more abundant. Planting six-rowed varieties in drier climates will result in reduced plumpness (or thinner grain). As plumpness is reduced, starch content decreases and the absolute amount of protein per kernel is maintained (although percentage of protein in the grain is increased). The least desirable effect of reduced plumpness is the relative increase in percent hull for the grain, resulting in an increase in the fiber content of thinner grain.

The majority of the barley planted is covered barley, meaning that the glume or hull is retained during the threshing process. Varieties where the hull is removed during threshing are called hull-less barleys and usually have a higher content of beta-glucans, a type of water-soluble fiber. Modifications of the type of starch stored in the grain are possible and waxy, hull-less barleys have been developed, primarily for use in human foods.

In addition, barleys may be classified according to their acceptability to the U.S. brewing industry. Barleys are classified as malting varieties if they have met the requirements of the brewing industry. Non-malting varieties are those not yet accepted for malting purposes in the U.S. or cultivars grown solely for feed purposes.

In practice, commercially designated feed barleys are those produced from feed cultivars or may be malting cultivar barleys where the grain did not qualify for malting grades. Grain produced from seed of malting cultivars may be labeled as feed barley if disqualified for malting because of a low percent of plump kernels, high protein, discoloration, or other characteristics.

U.S. Barley Grading Standards

U.S. grain grading standards are available in several formats, including from the World-Wide Web. An overview of the U.S. grading standards for barley is presented in Table 1.

Table 1. Grading standards for U.S. barley.[a]

Grade	Minimum Test Weight Lb/bu	Minimum Test Weight Kg/hl	Min. Sound Grain %	Maximum Foreign Material %	Maximum Broken Grain %	Maximum Heat Damaged Kernels %	Maximum Total Damaged Kernels %	Maximum Thin Barley %
U.S. No. 1	47	60.2	97	1	4	0.2	2	10.0
U.S. No. 2	45	58.7	94	2	8	0.3	4	15.0
U.S. No. 3	43	55.1	90	3	12	0.5	6	25.0
U.S. No. 4	40	51.2	85	4	18	1.0	8	35.0
U.S. No. 5	36	46.1	75	5	28	3.0	10	75.0

U.S. Sample grade shall be barley that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or (b) Contains 8 or more stones or any number of stones that have an aggregate weight in excess of 0.2 percent of sample weight, 2 or more pieces of glass, 3 or more seeds of crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cocklebur (Xanthium spp.) Or similar seeds singly or in combination, 10 or more rodent pellets, bird droppings, or equivalent quantity of animal filth per 1-1/8 to 1-1/4 quarts of barley; or (c) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or (d) Is heating or otherwise of distinctly low quality.

"Damaged kernels" includes heat-damaged kernels. Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels.

[a] Adapted from "The Official United States Standards for Grains," USDA, 1975, Washington, D.C.

Feeding Swine

Processing Barley

Barley to be fed to swine in the U.S. is rarely screened to remove traces of foreign material or to produce two lots differing in test weight. However, this practice is common in some countries where barley may also traditionally be dehulled as a value-added process.

Whole (or covered barley) may be ground using a hammer mill or a roller mill. Hammer mills typically are more effective in reducing the particle size of the hull than are roller mills. However, hammer mills are less efficient and produce more dust than roller mills. Roller mills would be expected to be more efficient and produce a more uniform particle size when used to grind hulless or dehulled barleys.

The preferred particle size for use in swine feeds is approximately 700 microns with a relatively small range in particle sizes to promote uniform mixing (Goodband, et al., 1997). Smaller particle sizes (down to an average size of approximately 400 microns) are associated with higher digestibility but with an increased incidence of esophago-gastric ulcers. Some types of fiber, such as that found in barley hulls, have been found to reduce the incidence of gastric ulcers in growing-finishing swine.

Pelleting barley-based swine diets will typically be expected to improve performance by 8 - 12% over that of pigs offered comparable diets as ground feed (meal-type diets) (Haugse, et al., 1966; Newman and McGuire, 1985). Extrusion of barley-based diets has not consistently produced an improvement over pelleting (Fadel, et al., 1988; Laurien, et al., 1998).

Swine diets in some areas are mixed with water and fed in paste or gruel consistency. Feeding moist diets usually reduces feed wasted and may improve voluntary intake of any diet. Because of the complications of offering moistened feeds, wet-feeding is frequently practiced when labor is relatively inexpensive or when feed costs are relatively high.

Feed Additives

Antimicrobials (antibiotics) are commonly added to swine diets in the U.S. for growth promotion and for disease prevention or control. Antibiotics are not permitted in certain other countries, where copper sulfate may be used as the growth promotant of choice. Zinc oxide may be used as a growth enhancer in diets for early-weaned pigs where it must be fed for approximately two weeks for greatest benefit.

Commercially-available enzyme preparations are becoming available at economially-justifiable prices. Beta-glucanases would be expected to produce the greatest response when used in diets containing naturally hull-less barleys intended for feeding to young pigs (Graham, et al., 1989). Responses to additions of beta-glucanases to diets based on covered barleys (intact or mechanically dehulled) and fed to swine have not been consistent. The bacterial populations in the digestive tracts of older swine appear to be able to hydrolyze beta-glucans to the point that few, if any, problems are encountered with beta-glucan levels found in covered barleys.

Concerns over nutrient buildup in soils to which swine wastes are applied make the inclusion of products that contain phytases very attractive. Phytase, the storage form of phosphorus in plant seeds, is relatively resistant to breakdown in the digestive tract of swine. While the phosphorus in barley is commonly considered to have a bioavailability of approximately 30%, the addition of phytases to swine diets could increase the digestibility of phosphorus in barley to about 60-70% .

Nutritional Advantages of Barley for Swine

The primary advantages of barley relative to alternative energy feedstuffs are in its higher content of digestible nutrients. The levels of bioavailable amino acids represent the greatest nutritional advantages of barley in comparison with alternative feed grains. The primary source of these advantages is in the higher content of essential amino acids, particularly lysine.

When calculated at common market values, the total package of available nutrients in barley typically has a value of at least 110% of that of the common alternative grains (based on recent calculations in our laboratory). The higher content of available amino acids more than compensates for the fact that barley may contain 94% of the digestible or metabolizable energy content of some cereals, such as corn or wheat, when fed as meal-type diets. Differences in energy content are minimized in pelleted diets (for example, see Graham, et al., 1989).

Barley contains more phosphorus than common cereal grains and that phosphorus has a higher bioavailability than the phosphorus of those grains. The net effect of higher levels of available phosphorus will typically represent an added value of approximately $1 per ton as a secondary economic advantage of barley relative to other feed grains.

Cereal grains are not considered to be good sources of vitamins and trace minerals. As a result, it is common practice to add the complete requirements of swine for vitamins and trace minerals in the form of premixes.

Non-Nutritional Factors that may be Present

A number of factors influence whether or not barley produced on the Northern Plains or other grain-producing regions of the world may contain varying levels of deoxynovalenol (DON), a fungal mycotoxin. Feeding any grain containing DON may be associated with feed refusal by swine. Nursery-age pigs may be most sensitive to this compound (Goodband, et al., 1997) and total diet recommendations of no more than 1-2 ppm DON are typical (for example, see Trenholm et al., 1994).

An overview of mycotoxins in feeds for several classes of livestock has been presented by Meronuck and Concibigo (1997).

Formulation of Swine Diets

The swine diets presented here were formulated with a least-cost program, "Professional Nutritionist - Swine" (Cornelius and Hartman, 1990) using default nutrient values.

Barley in Diets for Sows in Gestation

The nutritional requirements of sows during gestation provide an excellent opportunity to use thin barley screened from a sample of barley where screening into thin and plump lots is a common practice. By selectively utilizing thinner barley containing more dietary fiber, producers have an opportunity to enhance gastric capacity in their sows during gestation and thereby increase the opportunity for those sows to consume the maximum amount of the lactation diet after farrowing.

Developing gastric capacity in sows during gestation is becoming more critical as meeting the nutritional demands placed on the sow during lactation are increased. Field reports of sows consuming more than 22 pounds (10 kg) of feed per day during the peak of lactation are becoming relatively common. Providing a bulky diet in gestation fosters larger gastric capacity and also helps pacify the sows by retaining ingesta in the stomach longer during this period when they are fed restricted amounts of diet.

Barley-based diets fed during gestation should be offered as meal-type feeds where grinding and mixing are the only processing methods used. An example barley-based diet that may be fed during gestation is presented in Table 2.

Table 2. Example least-cost barley-based gestation diet.

Ingredient	% of Diet	Lb/Ton
Barley, ground	81.7	1634
Soybean meal, solvent	12.9	258
Dicalcium phosphate	2.4	48
Soybean oil	2.0	40
Limestone	0.5	10
Salt	0.3	6
Vitamin and trace minerals	0.2	4
Totals	100.0	2,000

Barley in Diets for Sows During Lactation

The onset of lactation represents a dramatic shift in the nutrient needs of the sow. While gestating sows are typically offered restricted amounts of mixed feed, lactating sows will need to be placed on a feeding schedule that quickly brings them to an *ad libitum* (full feeding) program. The rate at which lactating sows are brought up to a full-feeding program can vary with the individual genetic line of sows.

Some producers continue to restrict the amount of feed offered during early lactation in an attempt to minimize mastitis in the sows and (or) scours in the litter. Other producers have success with allowing *ad libitum* access to feed from the time that the sows are brought into the farrowing unit or immediately after farrowing. Where sows are permitted *ad libitum* access to feed immediately after farrowing, it is not uncommon for sows to gain modest amounts of weight during lactation.

The appetite displayed by these sows (rate of feed consumption) and the need to provide a large quantity of feed and nutrients to sows during lactation suggests that these diets should be pelleted. Barley can be a valuable cereal grain in lactation diets, particularly during early lactation where fiber intake has been shown to be beneficial in avoiding constipation in the sows.

An example barley-based diet for lactating sows is presented in Table 3.

Table 3. Example least-cost barley-based lactation diet.

Ingredient	% of Diet	Lb/Ton
Barley, ground	73.7	1474
Soybean meal, solvent	20.9	418
Dicalcium phosphate	2.3	46
Soybean oil	2.0	40
Limestone	0.5	10
Salt	0.3	6
Vitamin and trace mineral premixes	0.25	5
DL-Methionine	0.05	1
Totals	100.0	2,000

Barley in Diets for Nursery Pigs

A common objective in the nursery is to have the pigs consuming feed as quickly as possible so that weight gain and feed efficiency are optimized. Barley can serve as the sole cereal grain in well-formulated diets for young pigs and produce results equivalent to those obtained with other cereal grains. The initial diets used in the nursery should be offered as small pellets or crumbles to stimulate consumption and maximize nutrient digestibility. These initial diets are frequently very complex and include costly ingredients used because of their palatability and digestibility. The diets used in subsequent phases in the nursery become less complex and may not be pelleted if meal-type diets will be fed during the growing and finishing stages.

Age at weaning influences the number of dietary phases used in the nursery. Four phases are typically used with early weaning (approximately 14 days) while three dietary phases are common with conventional (21-day) weaning. Decisions to take nursery pigs to higher end-weights (50 to 60 pounds, for example, rather than 40 pounds) will influence the number of dietary phases and the nutrient levels chosen for the diet fed during the last nursery phase.

These diets typically have some flavor components used throughout the nursery program to provide a form of continuity as the complexity of the diets changes with age and weight of the pigs. The flavoring agents may be dried milk products or materials that mimic flavors found in various fruits (apples or strawberries) or flavors (licorice).

Example nursery diets containing barley are presented in Tables 4 and 5.

Table 4. Example least-cost barley-based diet for nursery pigs (7 kg or 15 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	26.7	534
Soybean meal, solvent	17.3	346
Oat groats	20.0	400
Dried whey	20.0	400
Dried porcine plasma	3.0	60
Spray-dried blood meal	3.0	60
Herring meal	3.0	60

Ingredient	% of Diet	Lb/Ton
Dicalcium phosphate	1.6	32
Soybean oil	4.0	80
Limestone	0.35	7
Salt	0.3	6
Vitamin and trace mineral premixes	0.3	6
Antibiotic	0.2	4
DL-Methionine	0.15	3
Flavoring agent	0.1	2
Totals	100.0	2,000

Table 5. Example least-cost barley-based diet for late-nursery pigs (14 kg or 30 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	52.4	1048
Soybean meal, solvent	24.5	490
Oat groats	15.0	300
Spray-dried blood meal	3.0	60
Dicalcium phosphate	1.7	34
Soybean oil	2.0	40
Limestone	0.6	12
Salt	0.3	6
Vitamin and trace mineral premixes	0.3	6
DL-Methionine	0.1	2
Flavoring agent	0.1	2
Totals	100.0	2,000

Barley in Diets for Growing-Finishing Pigs

The overwhelming majority of feed used in swine operations is fed to growing-finishing pigs. As a result, more is known about the nutrient requirements of these pigs and the development of "best cost" diets becomes critical. Diet formulation becomes heavily influenced by the genetic potential of the animals and by market dictates for carcass quality. Barley-based diets may be particularly effective in responding to the nutrient needs of the pigs and in emphasizing carcass quality.

The high levels of available essential amino acids present in barley contribute to the formulation of low-cost diets that are nutritionally effective in maximizing carcass quality. Publications containing nutrient recommendations for swine (for example, see NRC, 1998) should be consulted for estimated nutrient requirements for various classes of swine.

Barley having a test weight of at least 46 lb/bu or greater (59 Kg/hl or greater) can be fed to growing-finishing pigs in meal-type diets (as ground feed) without reducing average daily gain, daily feed intake, or feed- per-gain values relative to values obtained with barley having a test weight of 48 lb/bu (Harrold, et al., 1989).

Barleys having test weights of at least 44 lb/bu will produce results comparable to those of heavier barleys when the diets are fed in pelleted form. Barley with a test weight of less than 44 lb/bu (56.3 Kg/hl) test weight could result in suboptimal weight gain when fed to growing-finishing pigs in pelleted form (Harrold, et al., 1989).

Example barley-based diets for growing and finishing pigs of various weights are presented in Tables 6, 7, 8, and 9.

The suggested nutrient specifications used in developing the example diets for swine are presented in Table 10. Table 11 lists expected nutrient levels in barley and Table 12 lists ileal amino acid digestibility values of barley for swine.

Table 6. Example least-cost barley-based early-grower diets (20.5 kg or 45 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	66.3	1326

Soybean meal, solvent	28.8	576
Dicalcium phosphate	1.5	30
Soybean oil	2.0	40
Limestone	0.6	12
Salt	0.3	6
Vitamin and trace mineral premixes	0.25	5
Antibiotic	0.15	3
DL-Methionine	0.1	2
Totals	100.0	2,000

Table 7. Example least-cost barley-based diet for early-developer pigs (41 kg or 90 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	69.45	1389
Soybean meal, solvent	26.0	520
Dicalcium phosphate	1.1	22
Soybean oil	2.0	40
Limestone	0.8	16
Salt	0.3	6
Vitamin and trace mineral premixes	0.25	5
DL-Methionine	0.1	2
Totals	100.0	2,000

Table 8. Example least-cost barley-based late-developer diet (64 kg or 140 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	77.2	1544
Soybean meal, solvent	18.7	374
Dicalcium phosphate	0.6	12
Soybean oil	2.0	40
Limestone	0.9	18
Salt	0.3	6
Vitamin and trace mineral premixes	0.25	5
DL-Methionine	0.05	1
Totals	100.0	2,000

Table 9. Example least-cost barley-based late finisher diet (90 kg or 200 lb).

Ingredient	% of Diet	Lb/Ton
Barley, ground	79.7	1594
Soybean meal, solvent	16.6	322
Dicalcium phosphate	0.1	2
Soybean oil	2.0	40
Limestone	1.0	20
Salt	0.3	6
Vitamin and trace mineral premixes	0.2	4
DL-Methionine	0.1	1
Totals	100.0	2,000

Table 10. Example nutrient specifications for swine diets (modified from NRC, 1998).

Nutrient	7 kg (15 lb)	14 kg (30 lb)	22 kg (45 lb)
Crude protein, %	24.0	21.0	19.0
Lysine, %	1.4	1.2	1.1
Methionine + cystine, %	0.84	0.72	0.66

Threonine, %	0.91	0.78	0.72
Tryptophan, %	0.28	0.24	0.21
Calcium, %	0.9	0.8	0.75
Phosphorus, %	0.8	0.72	0.68

Nutrient	41 kg (90 lb)	64 kg (140 lb)	90 kg (200 lb)
Crude protein, %	18.5	17.0	16.0
Lysine, %	1.0	0.85	0.8
Methionine + cystine, %	0.62	0.53	0.51
Threonine, %	0.65	0.55	0.53
Tryptophan, %	0.19	0.15	0.14
Calcium, %	0.7	0.6	0.5
Phosphorus, %	0.6	0.5	0.4

Nutrient	Gestation	Lactation
Crude protein, %	14.0	16.0
Lysine, %	0.7	0.9
Methionine + cystine, %	0.43	0.56
Threonine, %	0.46	0.60
Tryptophan, %	0.13	0.18
Calcium, %	0.9	0.9
Phosphorus, %	0.8	0.8

Assumptions: All nutrient specifications are intended for diets to be fed to swine of high genetic potential. Growing swine should have a potential of gaining approximately 375 grams of lean tissue per day (0.82 lb). The specifications for growing and finishing swine are intended for gilts and should be somewhat reduced for barrows. Sows are expected to wean 10.0 pigs per litter with a litter weaning weight of at least 64 kg (140 lb) after a 21-day lactation. At least 90% of the sows should conceive at the first estrus after weaning. These specifications were developed with the assumption that phytase enzyme preparations were not added to the diets.

Table 11. Expected chemical composition of barley (as-fed basis).

Component	Units	NRC (1998)[1]	Regional Quality Survey (1998)[2]
Dry matter	%	89	90.82
Gross energy	kcal/kg	--	3751
Digestible energy	kcal/kg	3,050	
Metabolizable energy	kcal/kg	2,910	
Net energy	kcal/kg	2,310	
Crude protein	%	10.5	11.53
Crude fat	%	1.9	--
Linoleic acid	%	0.91	--
Fiber, neutral-detergent	%	18.6	18.00
Fiber, acid-detergent	%	7.0	7.09
Calcium	%	0.06	0.061
Phosphorus (Bioavailability = 30%)	%	0.36	0.379
Sodium	%	0.02	0.018
Chlorine	%	0.15	--
Potassium	%	0.47	0.533
Magnesium	%	0.12	0.132
Sulfur	%	0.15	--
Copper	mg/kg	8	5
Iron	mg/kg	88	51
Manganese	mg/kg	16	17
Selenium	mg/kg	0.10	--
Zinc	mg/kg	15	29
Biotin	mg/kg	0.14	--
Choline	mg/kg	1,034	--
Folacin	mg/kg	0.40	--
Niacin (Bioavailability in grains is assumed to be 0)	mg/kg	48	--
Pantothenic acid	mg/kg	7.0	--

Riboflavin	mg/kg	1.6	--
Vitamin B_6	mg/kg	2.9	--
Vitamin B_{12}	�g/kg	0	--
Vitamin E	mg/kg	7.4	--
Beta-carotene	mg/kg	4.1	--
Arginine	%	0.48	0.71
Histidine	%	0.22	0.24
Isoleucine	%	0.37	0.41
Leucine	%	0.68	0.62
Lysine	%	0.36	0.40
Methionine	%	0.17	--
Cystine	%	0.20	--
Phenylalanine	%	0.49	0.49
Tyrosine	%	0.32	0.30
Threonine	%	0.34	0.43
Tryptophan	%	0.13	--
Valine	%	0.49	0.45
Aspartic Acid	%	--	0.66
Glutamic acid	%	--	2.47
Serine	%	--	0.62
Glycine	%	--	0.59

[1] NRC(1998) values are for 6-rowed varieties.

[2] The regional Barley Crop Quality Survey is an annual survey of barley produced in North Dakota and major barley producing areas in Minnesota and South Dakota. The analyses presented here were conducted by the Department of Animal and Range Sciences, North Dakota State University.

Table 12. True ileal amino acid digestibility values (swine) for barley (NRC, 1998) (as-fed basis).

Arginine	%	86
Histidine	%	86
Isoleucine	%	84
Leucine	%	86
Lysine	%	79
Methionine	%	86
Cystine	%	86
Phenylalanine	%	88
Tyrosine	%	87
Threonine	%	81
Tryptophan	%	80
Valine	%	82

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Feeding Poultry

The discussion of processing methods and types of barley in the previous section (Barley as a Feedstuff for Swine) apply equally to poultry and swine. As a result, that material will not be duplicated here. In addition, generalized information on feeding poultry, including the use of barley in poultry diets, has been presented by Cole and Haresign (1989), Jurgens (1997), Larbier and Leclercq (1994), and Waldroup (1997).

A review of feeding barley to poultry has been published by Jeroch and Danicke (1995) and may be consulted for specific references on feeding barley to poultry. Nutrient specifications for the diets formulated for poultry were taken from NRC (1994) or Jurgens (1997).

Feed Additives

Poultry, particularly growing chickens, are sensitive to the beta-glucans in barley. Beta-glucans form gels in the digestive tract of birds that are not broken down because of the lack of appropriate enzymes and the rapid rate of passage in poultry. Without addition of beta-glucanases to the feed, barley-based diets have been associated with reduced levels of available energy and with wet droppings, pasty vents, and wet litter.

However, adding beta-glucanases to diets fed to poultry can effectively eliminate the problems with wet, gummy droppings while increasing the availability of dietary energy and reducing the effective variation in energy content.

The discussions that follow assume that enzymes have been added to the diet at levels recommended by the manufacturer of the appropriate product.

General Concepts of Feeding Barley to Poultry

The following points appear to apply to all classes of poultry (Jeroch and Danicke, 1995):

- Enzyme supplementation reduces undesirable effects such as wet droppings while also reducing intestinal weight.
- It appears that at least some beta-glucanases are heat-stable to processing conditions such as pelleting to a temperature of 85^{o}C.
- Suppliers of beta-glucanase enzyme preparations should be consulted for recommended levels of inclusion and information about stability to various processing conditions.
- Barley does not contain yellow pigments. Where egg yolk color or pigmentation of shank color and body fat are considerations, sources of pigmentation factors must be added to maintain desirable levels of color.
- When diets are formulated on a least-cost basis, barley from the Northern Great Plains of the U.S. may enter the formulation on the basis of energy and amino acid content.
- Levels of barley from the Northern Great Plains of the U.S. will be increased in least-cost formulations when economical sources of added fat are available.
- Spring barley cultivars may contain higher levels of available energy than winter- seeded cultivars.

Formulation of Diets for Poultry

All poultry diets in this section were formulated using a microcomputer spreadsheet to meet the calculated analyses listed for each diet. Analytical values were based on those presented by NRC (1994).

Broiler Chickens

Young broilers (less than three weeks of age) may receive diets containing up to 20% barley when supplemented with appropriate enzymes. From three to six weeks of age, broilers may be fed diets containing up to 40% enzyme-supplemented barley. This level may be increased to 50% of the diet for broilers over six weeks of age (Jeroch and Danicke, 1995).

Example diets containing barley and formulated to be fed to broiler chickens are presented in Table 13.

Table 13. Example diets for broiler chickens.

	Broilers From:		
	0-21 Days	21-42 Days	42-56 Days
	- - - - - % of Diet - - - - -		
Ingredient			
Barley	20.0	25.0	30.0
Corn	32.6	35.15	36.55
Soy - 48%	33.0	26.0	20.0
Menhaden meal	2.0	2.0	2.0
Alfalfa meal	3.0	3.0	3.0
Fat	6.0	6.0	6.0
Dical	1.5	1.0	0.65
Limestone[1]	1.1	1.2	1.2
Salt	0.35	0.35	0.35
Vitamin premix[2]	0.1	0.1	0.1
Trace minerals[2]	0.1	0.1	0.1
L-Lysine HCl	0	0	0
DL-Methionine	0.25	0.1	0.05
�-glucanase source	+	+	+
	-------	-------	-------
Total	100.0	100.0	100.0
Projected Analysis			
AMEn, kcal/kg	3101	3157	3203
CP, %	23.02	20.34	18.09
Lysine, %	1.26	1.08	0.92
Methionine	0.60	0.42	0.34
Total SAA[3]	0.97	0.75	0.64
Threonine	0.87	0.83	0.68
Tryptophan	0.32	0.27	0.24
Arginine	1.47	1.26	1.08

Calcium	1.00	0.91	0.82
Non-phytate phosphate	0.47	0.38	0.31

[1] Oyster shell or other ground sea shells may be substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

Growing Replacement Pullets

Recommendations for inclusion levels for young replacement pullets are comparable to those for broilers. Growing pullets over six weeks of age may be fed diets containing 50% to 60% barley in enzyme-supplemented diets Jeroch and Danicke, 1995). Limiting the amount of fat added to barley-based diets or deleting the added enzyme preparation can be effective methods for limiting mature size in caged layers.

Feeding Laying Hens

Hens often do not respond to enzyme supplementation until levels of barley exceed 25% of the diet (Jerock and Danicke, 1995). Adding enzyme supplements to diets containing 50% barley has produced results comparable to those obtained when the diet contained 10% barley. Diets containing barley in combination with rye or triticale should contain added enzymes.

Producers should add sources of pigmentation factors to diets containing more than 40% barley to maintain yolk color.

Example diets containing barley that were formulated to be fed to laying hens (producing white-shelled or brown-shelled eggs) or to breeding hens (producing white-shelled eggs) are presented in Table 14.)

Table 14. Example diets for laying hens producing white or brown eggs and for breeding hens.

	Leghorn-Type Hens Laying:		
	White Eggs	Brown Eggs	Breeders, White Egg
	- - - - - % of Diet - - - - -		
Ingredient			
Barley	40.0	30.0	35.0
Corn	26.05	29.0	29.05
Soy - 44%	15.0	20.0	16.0
Meat meal	2.0	2.0	2.0
Alfalfa meal	3.0	3.0	3.0
Fat	5.0	6.0	6.0
Dical	0.3	0.3	0.3
Limestone[1]	8.0	9.0	8.0
Salt	0.35	0.35	0.35
Vitamin premix[2]	0.1	0.1	0.1
Trace minerals[2]	0.1	0.1	0.1
L-Lysine HCl	0	0	0
DL-Methionine	0.1	0.15	0.1
L-Threonine	0	0	0
L-Tryptophan	0	0	0
Total	100.00	100.00	100.00
Projected Analysis			
AMEn, kcal/kg	2898	2899	2956
CP, %	15.17	16.5	15.29
Lysine, %	0.69	0.82	0.73
Methionine	0.33	0.40	0.34
Total SAA[3]	0.60	0.68	0.60
Threonine	0.56	0.62	0.57

Tryptophan	0.21	0.23	0.21
Arginine	0.86	0.98	0.88
Calcium	3.38	3.77	3.38
Non-phytate phosphate	0.27	0.27	0.27

[1] Oyster shell or other ground sea shells may be substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

Feeding Turkeys

Where growing turkeys received diet changes at four-week intervals, incremental levels of barley (0, 20, 35, 50, and 65%) replacing corn produced comparable body weight values at 20 weeks of age (approximately 27 lb). Enzyme supplementation is most effective for younger poults (Jeroch and Danicke, 1995).

Unpublished information suggests that poults more than 12 weeks of age are not likely to be affected by the presence of DON in grain samples. Turkey producers in the Northern Great Plains reportedly make extensive use of grain containing moderate levels of DON.

Example diets containing barley and formulated to be fed to turkey poults of various ages are presented in Tables 15 and 16.

Table 15. Example diets for growing turkeys: 0-4 weeks, 4-8 weeks, and 8-12 weeks of age.

	Age of Poults:		
	0-4 Weeks	4-8 Weeks	8-12 Weeks
	- - - - % of Diet - - - -		
Ingredient			
Barley	25.0	30.0	35.0
Corn	22.8	28.3	29.5
Soy - 48%	39.5	29.2	21.8
Menhaden meal	2.0	2.0	2.0
Alfalfa meal	3.0	3.0	3.0
Fat	4.0	4.5	5.2
Dical	1.6	1.25	1.1
Limestone[1]	1.2	0.9	0.8
Salt	0.35	0.35	0.35
Vitamin premix[2]	0.1	0.1	0.1
Trace minerals[2]	0.1	0.1	0.1
L-Lysine HCl	0.1	0.15	0.15
DL-Methionine	0.25	0.15	0.05
L-Threonine	0	0	0.05
�-glucanase source	+	+	+
Total	100.0	100.0	100.0
Projected Analysis			
AMEn, kcal/kg	2915	3035	3098
CP, %	26.01	22.05	19.12
Lysine, %	1.52	1.29	1.10
Methionine	0.64	0.49	0.35
Total SAA[3]	1.04	0.84	0.67
Threonine	0.98	0.83	0.77
Tryptophan	0.37	0.30	0.25
Arginine	1.68	1.37	1.14
Calcium	1.08	0.86	0.77
Non-phytate phosphate	0.51	0.43	0.40

[1] Oyster shell or other ground sea shells may be

substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

Table 16. Example diets for growing turkeys: 12-16 weeks and 16-20 weeks of age.

	Age of Poults:	
	12-16 Weeks	16-20 Weeks
	- - % of Diet - -	
Ingredient		
Barley	40.0	40.0
Corn	31.4	38.25
Soy - 48%	15.5	8.9
Menhaden meal	2	2.0
Alfalfa meal	3.0	3.0
Fat	6.0	6.0
Dical	0.8	0.6
Limestone[1]	0.7	0.6
Salt	0.35	0.35
Vitamin premix[2]	0.1	0.1
Trace minerals[2]	0.1	0.1
L-Lysine HCl	0	0.05
DL-Methionine	0.05	0.05
�-glucanase source	?	?
	------	------
Total	100.0	100.0
Projected Analysis		
AMEn, kcal/kg	3214	3284
CP, %	16.63	14.05
Lysine, %	0.82	0.68
Methionine	0.32	0.29
Total SAA[3]	0.60	0.54
Threonine	0.63	0.52
Tryptophan	0.22	0.17
Arginine	0.95	0.75
Calcium	0.65	0.56
Non-phytate phosphate	0.34	0.29

[1] Oyster shell or other ground sea shells may be substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

Feeding Ducks and Geese

Responses of ducks and geese to barley and to enzyme supplementation are comparable to those of other poultry (Jerock and Danicke, 1995). Enzyme supplements produce the greatest responses in young birds and permit increased levels of barley in the diet for the younger birds.

Little information about the tolerance of ducks and geese to DON is available. Until more information is available, it maybe prudent to avoid feeding diets containing more than 1.0 ppm total DON to ducks and geese.

Example diets containing barley and formulated to be fed to geese or to ducks are presented in tables 17 and 18, respectively.

Table 17. Example diets for geese.

	Type of Bird:		
	0-4 Weeks	4+ Weeks	Breeders
	- - - - % of Diet - - - - -		
Ingredient			
Barley	30.0	35.0	40.0
Corn	31.45	41.0	31.2
Soy - 44%	30.2	16.4	17.0
Alfalfa meal	3.0	3.0	3.0
Fat	3.0	2.0	2.0
Dical	1.0	1.0	1.0
Limestone[1]	0.8	0.8	5.0
Salt	0.35	0.35	0.35
Vitamin premix[2]	0.1	0.1	0.1
Trace minerals[2]	0.1	0.1	0.1
L-Lysine HCl	0	0.2	0.2
DL-Methionine	0	0.05	0.05
�-glucanase source	+	+	?
Total	100.0	100.0	100.0
Projected Analysis			
AMEn, kcal/kg	2910	2995	2827
CP, %	20.02	15.54	15.55
Lysine, %	1.04	0.87	0.88
Methionine	0.31	0.30	0.29
Total SAA[3]	0.64	0.57	0.56
Threonine	0.76	0.57	0.58
Tryptophan	0.30	0.21	0.22
Arginine	1.24	0.87	0.87
Calcium	0.68	0.64	2.25
Non-phytate phosphate	0.35	0.33	0.33

[1] Oyster shell or other ground sea shells may be substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

Table 18. Example diets for ducks.

	Age or Type of Duck:		
	0-2 Weeks	2-7 Weeks	Breeders
	- - - % of Diet - - - -		
Ingredient			
Barley	30.0	35.0	40.0
Corn	25.15	39.0	29.9
Soy - 44%	36.2	18.6	17.0
Alfalfa meal	3.0	3.0	3.0
Fat	3.0	2.0	2.0
Dical	1.35	1.0	1.0
Limestone[1]	0.65	0.8	6.5
Salt	0.35	0.35	0.35
Vitamin premix[2]	0.1	0.1	0.1
Trace minerals[2]	0.1	0.1	0.1
DL-Methionine	0.1	0.05	0.05
�-glucanase source	+	+	?

	-------	-------	-------
Total:	100.0	100.0	100.0
Projected Analysis			
AMEn, kcal/kg	2836	2970	2777
CP, %	22.18	16.16	15.26
Lysine, %	1.19	0.77	0.71
Methionine	0.43	0.31	0.29
Total SAA[3]	0.79	0.59	0.56
Threonine	0.85	0.61	0.57
Tryptophan	0.34	0.23	0.22
Arginine	1.40	0.93	0.87
Calcium	0.71	0.65	2.81
Non-phytate phosphate	0.43	0.33	0.33

[1] Oyster shell or other ground sea shells may be substituted for limestone on an equal weight basis.

[2] The amount of vitamin and trace mineral premixes included in each diet may need to be adjusted to reflect the concentration of individual nutrients in the premix.

[3] Total sulfur-containing amino acids represents the sum of the calculated methionine plus the cystine content of the diet.

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