Feed Preference Index on Cereal Grains for Poultry

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Abstract

Cereal grains provide the bulk of the energy in poultry feeds; therefore, the utilization and digestion of cereal grains are important. Thirteen different feeds were prepared for this research project. The cereal grains were added to the feed in the replacement of corn and included wheat, barley, sorghum, and dry corn. They were added to the diet at 17, 34, and 51 percent with slight adjustments for protein content. A control feed was formulated with good quality corn as the only cereal grain. Feed preference was determined by two ways, through adult roosters and growing chickens. Two containers were given to each rooster; one containing the control feed and the other containing a test feed. These two feeds were weighed and the feed was given to the rooster for 24 hours. The amount of feed remaining after this period was weighed and the containers were filled again. The roosters showed no significant preference for any type of feed. The growing chicken portion of the experiment was used to determine feed preference and also the metabolizable energy of the feed. Each sample feed and the control feed was tested on four cages of six chicks. The chicks began the trial at hatch and continued for 19 days. At the end of the trial, the chicks and the grams of feed consumed were weighed and the amount of weight gain per gram of feed was calculated. For a two day period, the amount of feed eaten was determined and the amount of excreta was collected and weighed. Using a bomb calorimeter, the amount of calories was determined in the feed and excreta. The apparent metabolizable energy (AME) of each feed was calculated. The feed intake, chicken weight, and feed to gain ratio were not significant different for the wheat, barley, and low yield corn. The best weight gain was for the control feed at 593 grams per chick for the nineteen day period and the lowest was 34% sorghum at 521 grams. The sorghum had a linear decrease in the feed intake and as the percentage of sorghum increased the feed intake decreased. Feed consumption was 750 grams for chicks fed 17% sorghum and 648 grams for chicks fed 51% sorghum. The feed to gain ratio for chicks fed 17% sorghum was 1.31 and was 1.24 for chicks fed 51% sorghum. The AME for barley showed a linear decrease. This linear decrease did not induce an increase in feed consumption to offset the decrease in energy. This may contrast the idea that chickens will consume enough energy to meet their needs. Also, wheat, sorghum, and dry corn decreased the amount of weight gain in the chicks. Hulless barley may prove to be an option for feeds in parts of the world where it is economically viable.

Introduction

Cereal grains are grasses that are cultivated particularly for their grain or fruit. They prove to be a rich source of carbohydrates and are often the staple of any diet. Corn, wheat, and rice account for 87% of all grain produced annually. Cereal grains provide the bulk of the energy in poultry feeds; therefore, the utilization and digestion of cereal grains are important. Starch is the component of energy in cereal grains and the digestion of starch is incredibly important. Generally, 90% of starch digestion occurs before the ileum and 98% is digested before the posterior ileum (Weurding et al. 2001). The major impediment to starch digestion is the soluble cell-wall polysaccharides or a protein matrix that encapsulates the starch (Classen 1996). Starch granules differ in size in different feedstuffs and the smaller granules will digest more quickly. Along with the cell wall and granule size, the presence and proportion of amylose and amylopectin molecules forming the starch granules will impact digestibility (Weurding *et al*. 2001). Even though a particular cereal grain may have high starch content, there is no correlation between the starch content of the cereal grain with the apparent metabolizable energy, but there is a strong correlation between the amount of digestible starch in the grain with the apparent metabolizable energy. Starch digestibility can be different for different grains and also for different samples within a cereal grain (Classen 1996).

Energy content of cereal grains can be stated as apparent metabolizable energy (AME), metabolizable energy (ME), and the true metabolizable energy (TME). The AME is the difference between the amount of energy consumed and lost from the animal. The TME corrects for energy components lost into the digestive system, so this number will always be higher than the AME. ME and TME energy can also be corrected for nitrogen retention, indicated as Men and TMEn. It could be argued that nitrogen is lost in the excreta as products of tissue protein catabolism. This results in an energy loss in manure from the excretion of this excess nitrogen. The nitrogen is expelled in the form of uric acid, which contains energy and if the amount of nitrogen excreted is increased, then so is the amount of uric acid. The energy values with this adjustment to nitrogen excretion will correct to nitrogen balance (King 1998).

Corn is by far the dominant cereal grain grown in the world, with the United States of America growing almost half of the world's supply. The TME of corn has been calculated to be around 4,007 kcal/kg (Zhai and Zhang 2007). A different milling technique on corn, such as hammer-milled or roller-milled, does not seem to affect the ileal digestion of the cereal grain, which seems to be around 97%. The starch digestion rate was faster in roller-milled corn than hammer-milled corn. The different processing may have resulted in different size particles and other particle properties, such as particle shape, and this may have changed the passage rate and the starch digestion rate (Weurding *et al.* 2001).

Wheat is the second most produced cereal crop. The amount of AME in wheat is in the range of 3,340 to 3,650 kcal/kg and the ME around 3,050 to 3,770 kcal/kg (Scott *et al.* 1998). This observed difference could be because of numerous factors. The amount of starch digestion in wheat will depend on the amount of surface area available, with an increase of surface area increasing the digestibility. The starch granules in wheat are embedded in a protein matrix and the differences in the nutritional value of wheat will depend on how rapidly the protein matrix can be digested to allow access to the starch granules. The starch in wheat, if accessed, can be 100% digestible by the animal and therefore, is a potentially large supplier of energy for the bird (Guierrez-Alamo *et al*. 2007).

Barley is often grown on land that is too poor or where the climate is too cold for the growth of wheat. Barley generally has its fibrous hull removed before consumption. The fiber present in the hull will reduce the nutritional content of the feed, but has no anti-nutritional impact. The presence of the higher amount of fiber prevents the barley from being adequately digested but the introduction of enzymes has allowed the chicken to digest this more easily (Svihus and Gullord 2002). Chickens fed the hulless barley will have an increase in weight compared to those fed hulled barley without the addition of enzymes. Barley's AME values were in the range of 2,890 to 3,290 kcal/kg. Its TME was between 2,810 to3,480 kcal/kg for 33 different samples (Scott *et al.* 1998).

Milo is part of the cereal grain with the genus *Sorghum* and these plants are generally grown in warmer climates. The digestible energy value for milo was found to be from 3,490 to 4,190 kcal/kg (May and Nelson 1973).

Poultry nutritionists say that a chicken will potentially eat to meet its energy needs; therefore, if a feed has a low ME/kg, a chicken will eat more of it to compensate for lower energy content (Hill *et al.* 1956). In contrast, swine has shown a feed preference for different cereal grains based on odor, taste, texture, and particle size (Sola-Oriol *et al*. 2007). In the poultry industry, there has been little research done specifically for feed preference. The experiments that have touched upon it have shown that there is a change in the amount ingested of different types of cereal grains and this difference in the amount consumed has impacted the amount of energy consumed (Klein *et al*. 2001). To this end, the following study was conducted with the objective to determine if feed preference would affect the caloric intake of poultry. With an increase in caloric intake, the broilers would have an increase in weight gain and a decrease in the amount of time required obtaining a certain weight.

Procedures and Methodology

Thirteen different feeds were prepared with cereal grains replacing corn. All diets were formulated to 22% protein and nutritionally balanced with respect to protein. Protein content in the different cereal grains affected the percentage of soybean meal needed, but grains were included at 17, 34, and 51 percent of the diet. The cereal grains utilized were wheat, barley, sorghum, and dry corn. Dry corn is a corn in which the yield in the field was reduced to approximately half in comparison to regular corn. A control feed was also formulated with good quality corn as the only cereal grain.

Particle size of the feed samples was determined by using a sieve. The proportions of the feed in each pan were used to compare particle size for each type of feed. This will show whether the any preference could possibly be based on particle size.

Feed preference was determined in adult roosters and growing chickens. The feed preference determination using roosters required 13 different roosters. Two containers were given to each rooster; one containing the control feed and the other containing the test feed. These two feeds were weighed and the feed was given to the rooster for 24 hours. The amount of feed remaining after this period was weighed and the containers were filled again. The containers' positions were switched, either right or left, to cancel the effect of a rooster's preference for the right or left position. Roosters that displayed a preference for consuming feed only from either the left or right would not have shown a preference based on the taste or palatability of the feed. The amount of feed consumed was recorded for three days, and this portion of the experiment was repeated with four different roosters per treatment. The proportion of the experimental feed consumed was calculated.

The growing chicken portion of the experiment was used to determine feed preference and also the ME of the feed. Each sample feed and the control feed was tested on four cages of six chicks. The chicks began the trial at hatch and continued for 19 days. At the end of the trial, the chicks and the amount of feed consumed were weighed and the amount of weight gain per gram of feed was calculated. For a two day period, the amount of feed eaten was determined and the amount of excreta was collected and weighed. Using a bomb calorimeter, the amount of calories was determined in the feed and excreta. The amount of AME per kilogram of feed and the AME consumed by the chicks were calculated. There were four replicates of this portion of the experiment.

Statistical analysis was used to determine any linear or quadratic relationship between the percentages in the test feeds. Also, analysis was done among percentages across test feeds and comparing each test feed to each other. This was done using the SAS® Macro Application. This was applied to the rooster and growing chick portion of the experiment.

Results

The nutritional analysis of the different grains can be found on Table 1. Protein content of individual grains varied from 7.9 to 14.13%. The fat varied from 3.02% for wheat and 7.00% for corn. The ADF was the lowest percentage for barley at 1.91 and the highest for the dry corn at 7.2%.

Table 1: Analyzed Nutrient Content of Grains

Grain	Protein %	Fat %	ADF %
Corn	7.90	7.00	4.94
Dry Corn	9.72	6.43	7.20
Sorghum	11.12	7.30	6.80
Wheat	12.88	3.02	4.02
Barley	14.13	3.39	1.91

The formulated diets for the control and the 51% diets can be found on Table 2. All diets were prepared to contain 22% protein, 0.85% methionine and cystine, 1.18% lysine, 1.00% calcium, 0.45% non phytate phosphorus, and 4.40% fat.

Table 2: Diet Composition when Grains were Substituted for

Ingredient	Grains				
	Corn	Dry Corn	Sorghum	Wheat	Barley
Corn	60.37	11.31	13.34	13.03	14.93
Dry Corn	-	51.00	-	-	-
Sorghum	-	-	51.00	-	-
Wheat	-	-	-	51.00	-
Barley	-	-	-	-	51.00
Soybean meal	34.78	32.58	30.79	29.03	27.45
Dicalcium Phosphate	1.77	1.73	1.68	1.71	1.55
Limestone	1.33	1.36	1.38	1.36	1.49
Salt	0.40	0.40	0.40	0.40	0.40
Oil	1.00	1.29	0.85	3.03	2.84
Vitamins and Minerals	0.20	0.20	0.20	0.20	0.20
Methionine	0.15	0.13	0.24	0.14	0.14
Lysine – HCl	-	-	0.13	0.10	0.09

The results of sieving show that the particle size did not vary substantially between the feeds or change as the percentage of test cereal grain increased (Table 3). The fraction of the total feed in the 3/8" sieve was highest for 51% barley at .14 and lowest for 35% wheat at 0%. The amount present at the bottom of the pan was lowest for 35% wheat at 0% and highest for 17% wheat and 17% sorghum.

Table 3. Fraction of total feed retained by each sieve[1]

			US Sieve No.[3]				
Source[2]	Level %	3/8"	8	16	30	50	Pan
DC	17	0.08	0.35	0.31	0.10	0.07	0.06
	35	0.05	0.33	0.37	0.10	0.09	0.05
	51	0.07	0.37	0.36	0.07	0.08	0.05
W	17	0.05	0.36	0.37	0.08	0.06	0.07
	35	0.00	0.02	0.02	0.00	0.00	0.00
	51	0.06	0.40	0.31	0.10	0.07	0.05
S	17	0.05	0.35	0.37	0.08	0.08	0.07
	35	0.04	0.34	0.37	0.10	0.11	0.03
	51	0.02	0.30	0.39	0.12	0.10	0.05
B	17	0.07	0.35	0.38	0.07	0.12	0.02
	35	0.10	0.39	0.32	0.10	0.08	0.01
	51	0.14	0.43	0.26	0.12	0.05	0.01

[1] Values for the control diet were; 8, 0.071; 16, 0.327; 30, 0.301; 50, 0.159; pan, 0.124.
[2] DC, low yield corn; W, wheat; S, sorghum; B, barley

[3] US Sieve No. relates to US sieve opening; 8, 2.38 mm; 16, 1.19mm; 30, 420um; 50, 297um

The results of the rooster feed preference determination showed no significant difference between the control and the sample feeds. This is true across the types and percentages of feed available to the roosters. The 34% dry corn diet had the least consumed at 0.44 and the feed with the greatest preference was the 34% barley diet at 0.58.

The growing chick portion of the experiment is shown on Table 4. The 17% sorghum diet had the highest feed intake with 750 grams and 51% sorghum had the lowest with 648 grams consumed per chick. The feed intake for sorghum had a linear decrease ($P<0.05$). As the percentage of sorghum increased, the amount of feed intake decreased. The rest of the cereal grains showed no significant effect on the feed intake. The control had the best weight gain at 593 grams per bird and the 34% sorghum had the lowest with 521 grams. There was no significant difference for the chick weight for either the type of cereal grain or the percentage addition of the cereal grains. The feed to gain ratio was the highest for the 17% sorghum at 1.31 and the lowest for sorghum 51% with 1.24. There was a linear decrease in the feed to weight ratio ($P<0.05$). As the percentage of test cereal grain increased, the feed to weight ratio decreased. This occurred between percentages and in the sorghum test feed. The highest AME was for the 17% wheat with 3085 kcal/kg and 51% barley had the lowest AME with 2882 kcal/kg. Barley showed a linear decrease in the amount of energy available per kilogram as the percentage of barley in the feed increased (P<0.05). No other cereal grains showed a significant difference in their AME. The cereal grain with the highest metabolizable energy consumed per bird per day was 17% barley at 124 kcal and the lowest was 51% sorghum at 100 kcal. The barley showed a decrease in the AME consumed per day as the percentage of cereal grains was increased in the test feeds.

Table 4. Chick performance when fed diets with different types and levels of cereal grains[1]

Source[2]	Level %	Feed (g)	Weight (g)	F/W	AME (kcal/kg)	AME/B/D
DC	17	721	561	1.28	3036	115
	34	761	583	1.31	3058	122
	51	736	559	1.32	3036	118
S	17	750	575	1.31	2995	118
	34	666	521	1.28	3014	106
	51	648	524	1.24	2911	100
W	17	694	530	1.31	3085	113
	34	689	530	1.30	3067	111
	51	690	543	1.27	3052	111
B	17	777	593	1.31	3056	125
	34	759	586	1.29	2990	119
	51	709	566	1.25	2883	108

Probability (P≥ [t])

Expt Linear	0.06	NS	0.01	NS
Sorghum Linear	0.01	NS	0.01	NS
Barley Linear	NS	NS	NS	0.0003

[1] Values for chick fed the control diet were; feed, 755; weight, 593; Feed/wt, 1.27; AME, 3055; AME/B/D, 121

[2] DC, Low Yield Corn; S, Sorghum; W, Wheat; B, Barley

Discussion

Any differences in the consumption of the feeds cannot be attributed to the particle size due to the fact that the sieving showed no difference in the size of the particles between the feeds. Also, the consumption variability cannot be attributed to taste preference, as the roosters did not show a preference between the control feed and feed with the alternative cereal grain additions.

Interestingly, chick performance did show some variety with the addition of different cereal grains. Sorghum showed that at higher additions of this cereal grain, the amount consumed decreased. This decrease occurred even though the AME of the different sorghum feeds was not significantly different. This caused the chicks on the 34% and 51% sorghum diets to receive less energy per day.

Barley showed a significant decrease in the amount of AME available as the amount of barley in the feed increased. While there was no significant decrease in the amount of feed consumed by the chicks, there was a slight decrease in the consumption of the barley diet when barley was added at higher percentages. Due to this fact, the chicks were also receiving less AME per day due to the decrease in the AME of the feed without an increase in the amount consumed.

The results of this experiment showed that that the birds consumed less energy per day, they did not increase the feed eaten to maximize energy consumption. This is in contrast to existing research that an animal will consume to meet its energy requirements and stop eating (Hill *et al.* 1956). If such was the case, then the amount of energy received each day by the birds would be equal or not show a pattern. This strengthens the research that animals have may not have the ability to completely regulate their energy consumption and may be influenced by other factors (Sola-Oriol *et al.* 2007; Klein *et al*. 2001). Further research should be done on the gut fill of these different feeds to ensure that it is not impacting the amount of feed consumed by the animals.

The chicks did not grow as well when fed wheat, barley, or sorghum; therefore, they are not a suggested cereal grain for broilers. In contrast, hulless barley may be a cereal grain to consider in the parts of the world where it is an economically viable option.

Bibliography:

Classen, H.L. (1996). Cereal grain starch and exogenous enzymes in poultry diets. *Animal Feed Science Technology*, *62*(1), 21-27.

Guierrez-Alamo, A., de Ayala, P., Verstegen, M.W., Hartog, L.A., & Villamide, M.J. (2008). Variability in wheat: factors affecting its nutritional value. *World's Poultry Science Journal*, *64*(1), 20-39.

King, R.D. (1998). Linear model of nitrogen balance and examination of the nature of true metabolisable energy and its nitrogen corrected form. *British Poultry Science, 39*(1), 70-78.

Klein, M., Neubert, M., Hoffmann, L., Jentsch, W., Beyer, M., Scholze, H., & Kuhla,. S. (2001). Energy metabolism of cocks and broiler chickens fed on diets with different carbohydrate sources. *Archives for Animal Nutrition*, *55*(3), 207-220.

Hill, F.W., Anderson, D.L., & Dansky, L.M. (1956). Studies of the energy requirements of chickens. 3. The effect of dietary energy level on the rate and gross efficiency of egg production. *Poultry Science*, *35*, 54-59.

May, M.A., & Nelson, T.S. (1973). Digestible and metabolizable energy content of varieties of milo for rats. *Journal of Animal Science*, *36*(5), 874-876.

SAS. (1996) PROC MIXED statistical model. Cary, NC.

Scott, T.A., Silversides, F.G., Classen H.L., Swift, M.L., Bedford, M.R., & Hall, J.W. (1998). A broiler chick bioassay for measuring the feeding value of wheat and barley in complete diets. *Poultry Science*, *77*(3), 449-455.

Sola-Oriol, D. Roura, E., Torrallardona, D. (2007). Pig preference for cereal based diets, relationship with their digestibility and physical properties. *Livestock Science*, 108, 190-193.

Svihus, B., & Gullord, M. (2002). Effect of chemical content and physical characteristics on nutritional value of wheat, barley and oats for poultry. *Animal Feed Science and Technology*, *102*(1-4), 71-92.

Weurding, R.E., Veldman, A., Veen, W., van der Aar, P.J., & Verstegen, W.A. (2001). Starch digestion rate in the small intestine of broiler chickens differs among feedstuffs. *The Journal of Nutrition. 131*(9). 2329-2335.

Wiseman, J. (2000). Correlation between physical measurements and dietary energy values of wheat for poultry and pigs. *Animal Feed Science and Technology, 84*(1-2), 1-11.

Zhai, S.W., & Zhang, M.L. (2007). Comparison of true metabolisable energy and true amino acid availability between normal maize and quality protein maize. *Italian Journal of Animal Science*, *6*(3), 289-294.