

Performance of Broiler Chicks Fed Normal and Low Viscosity Rye or Barley with or without Enzyme Supplementation

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ABSTRACT : This experiment was conducted to measure nutrient digestibility and performance in broiler chicks fed diets based on normal and low viscosity rye or barley fed with and without enzyme (pentosanase and β -glucanase) during a 17 day growth trial. A total of 150 one-day old, male broiler chicks (5 birds per pen and 5 pens per treatment) were randomly assigned to one of six dietary treatments in a 3x2 factorial design experiment (3 cerealsx2 enzyme levels). Digestibility coefficients were determined using chromic oxide. Digestibility coefficients for dry matter and crude protein were significantly ($p=0.0001$) higher for the barley-based diets than for any of the rye-based diets. Digestibility coefficients for gross energy did not differ ($p>0.05$) due to cereal grain. There were no differences in the digestibility coefficients for dry matter and gross energy between chicks fed normal and low viscosity rye. However, the digestibility coefficient for crude protein was higher ($p=0.01$) for the low viscosity rye compared with the normal viscosity rye. Addition of enzyme to the diet significantly ($p=0.0001$) increased digestibility coefficients for dry matter, crude protein and energy. There were no significant differences in weight gain, feed intake or feed conversion between birds fed barley or rye or between birds fed normal or low viscosity rye. Enzyme supplementation significantly improved ($p=0.0001$) weight gain, intake and feed conversion. The overall results of this experiment indicate that unsupplemented barley and rye do not support adequate growth rates in poultry. Enzyme supplementation dramatically improved broiler performance. In addition, genetic selection to reduce the viscosity of rye had only a modest effect on the nutritive value of rye for broilers. (*Asian-Aust. J. Anim. Sci.* 2003, Vol 16, No. 2 : 234-238)

Key Words : Barley, Rye, Viscosity, Digestibility, Performance, Broiler

INTRODUCTION

Rye (*Secale cereale*) is not widely utilized as an energy source in poultry rations (North and Bell, 1990). The classical explanation for this relates to its high ergot content (Patrick and Schaible, 1980) resulting in relatively poor performance when broilers are fed rye-based diets (Cheeke, 1997). While ergot is undoubtedly toxic, research has shown that rye also contains soluble pentosans that also reduce broiler performance (Antonioni et al., 1981; Pettersson and Aman, 1988). Pentosans partially solubilize during digestion resulting in a highly viscous intestinal fluid that interferes with digestion (Campbell et al., 1983; Fengler et al., 1988). The negative effects of pentosans can be partially overcome by supplementation of the diet with pentosanase (GrootWassink et al., 1989; Teitge et al., 1990; Bedford et al., 1991).

An alternative method of improving the nutritional value of rye would be to reduce the soluble pentosan content, thereby reducing diet viscosity. Recently, a breeding program was undertaken at the Agriculture and Agri-Food Research Station in Swift Current, Saskatchewan to improve the nutritive value of rye. The objective of the following study was to compare the performance of broilers

fed diets based on normal or low viscosity rye in order to more fully understand the importance of viscosity as a factor affecting the nutritional value of rye for poultry.

MATERIALS AND METHODS

Acquisition of rye samples

The normal viscosity variety of rye fed in this experiment was developed at the Agriculture and Agri-Food Research Station in Swift Current, Saskatchewan and is marketed as the cultivar AC Rifle (McLeod and Payne, 1996). The low viscosity variety was derived from an introduction called Saratov. The sample was developed by conducting two cycles of recurrent mass selection within the variety Saratov. Extract viscosity (Gan et al., 1996) was determined on two hundred plants in the fall of 1996. In the summer of 1997, the 20% of lines with the lowest extract viscosity were allowed to inter-pollinate. In 1998, another two hundred plants were selected from the reconstituted population and the 20% of lines with the lowest extract viscosity were used to reconstitute the low viscosity population. This material was increased in 1999 in order to obtain sufficient material to conduct a feeding trial. All rye used was cleaned of ergot contamination removing that variable from the experiment.

Growth trial

A total of 150 one-day old, male broiler chicks (Ross-

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308 line; Lilydale Hatchery, Wynyard, Saskatchewan) were randomly assigned to one of six dietary treatments in a 3×2 factorial design experiment (3 cereal grains×2 enzyme levels). The cereal component of the diet (approximately 60%) comprised either barley, low viscosity rye or normal viscosity rye fed with or without enzyme (Table 1). Soybean meal (32%) was used as the source of supplementary protein and all diets were supplemented with sufficient vitamins and minerals to meet or exceed the levels recommended by the NRC (1994). The experimental diets were provided in mash form (3 mm screen) and the experiment was conducted over a 17 day period.

The enzyme supplement (*Aspergillus niger*, GNC Bioferm Incorporated, Saskatoon, Saskatchewan) supplied 2250 pentosanase units and 700 β-glucanase units per gram (unit is mg total reducing sugars (glucose equivalent) released in 10 min at 30°C and pH 4.0; manufacturer's specifications) as well as lesser quantities of other enzymes (cellulase, amylase, arabinofuranosidase and pectinase). Previous work has shown the enzyme to have activity at a pH below 2.5 and at temperatures in excess of 60°C (GrootWassink et al., 1989).

The chicks were housed in raised-floor battery cages (83.8 cm×45.7 cm×25.4 cm; Jamesway Manufacturing Co., Ft. Atkinson, WI, USA) with five birds per pen and 5 replicate pens per treatment. Feed and water were available ad libitum throughout the experiment. The battery brooder was maintained at a temperature of 35°C for the first week with the temperature gradually reduced to 29°C by the end of second week. Incandescent lighting was provided continuously during the experiment.

Broilers were weighed individually at the start (day 1) and end of the experiment (day 17). Weighed amounts of

feed were added as required with a single weigh back at the conclusion of the experiment to allow for the calculation of feed consumption and feed conversion on a pen basis.

Digestibility determination

Chromic oxide (0.5%) was added to all diets as a digestibility marker and was fed throughout the experimental period. During the final three days of the experiment, feces were collected from each pen. The fecal samples were frozen for storage. Prior to analysis, the samples were dried in a forced oven dryer at 55°C for 72 h, followed by fine grinding. The digestibility coefficients for dry matter, crude protein and energy were determined using the equations for the indicator method described by Schneider and Flatt (1975).

Chemical analysis

Samples of the experimental diets and feces were analysed according to the methods of the Association of Official Analytical Chemists (1980; Table 2). Analyses were conducted for moisture (AOAC method 930.15), crude protein (AOAC method 984.13), acid detergent fibre (AOAC method 973.18), ash (AOAC method 942.05) and ether extract (AOAC method 920.39). An adiabatic oxygen bomb calorimeter (Parr, Moline, Illinois) was used to determine gross energy. Diet viscosity was determined following the method of Scoles et al. (1993). A 0.3 g sample of diet was mixed with 900 µL of 0.1 M sodium acetate buffer (pH 5.0) and incubated 30 min at 40°C. The slurries were centrifuged (5.0 min at 12,000×g), the supernatant decanted and viscosity (centipose) read using a Brookfield cone-plate viscometer (Model LVTDCP-11, Brookfield Engineering Laboratories Inc., Stoughton, MA) maintained

Table 1. Formulation of experimental diets fed to determine effects of normal or low viscosity rye or barley fed with or without enzyme on broiler performance

	Diets without enzyme supplementation			Diets with enzyme supplementation		
	Barley	Low viscosity rye	Normal viscosity rye	Barley	Low viscosity rye	Normal viscosity rye
Barley	60.04	-	-	59.94	-	-
Low viscosity rye	-	60.04	-	-	59.94	-
High viscosity rye	-	-	60.04	-	-	59.94
Soybean meal	32.00	32.00	32.00	32.00	32.00	32.00
Tallow	4.00	4.00	4.00	4.00	4.00	4.00
Limestone	1.16	1.16	1.16	1.16	1.16	1.16
Dicalcium phosphate	1.27	1.27	1.27	1.27	1.27	1.27
Salt	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.20	0.20	0.20	0.20	0.20	0.20
Chlorine chloride	0.08	0.08	0.08	0.08	0.08	0.08
Premix ¹	0.50	0.50	0.50	0.50	0.50	0.50
Enzyme	-	-	-	0.10	0.10	0.10
Chromic oxide	0.50	0.50	0.50	0.50	0.50	0.50

¹ Supplied per kilogram of diet: 11,000 IU vitamin A (retinyl acetate+retinyl palmitate), 2,200 IU vitamin D₃, 30 IU vitamin E (dl-α-topheryl acetate), 2.0 mg menadione, 1.5 mg thiamine, 6.0 mg riboflavin, 60 mg niacin, 4 mg pyridoxine, 0.02 mg vitamin B₁₂, 10.0 mg pantothenic acid, 6.0 mg folic acid, 0.15 mg biotin, 0.625 mg ethoxyquin, 500 mg CaCO₃, 80 mg Fe, 80 mg Zn, 80 mg Mn, 10 mg Cu, 0.8 mg I, 0.3 mg Se.

Table 2. Chemical analysis of experimental diets fed to determine effects of normal or low viscosity rye or barley fed with and without enzyme on broiler performance (% as fed)

	Diets without enzyme supplementation			Diets with enzyme supplementation		
	Barley	Low viscosity rye	Normal viscosity rye	Barley	Low viscosity rye	Normal viscosity rye
Moisture	10.72	11.06	10.80	10.11	10.98	10.85
Crude Protein	18.83	19.89	19.03	18.20	19.70	18.76
Acid detergent fiber	7.81	8.23	8.05	7.86	8.44	7.87
Ether extract	5.56	5.56	5.61	5.61	5.56	5.65
Ash	5.94	5.84	5.84	5.97	5.87	6.17
Viscosity (cp)	1.31	4.43	9.78	1.72	4.77	7.39
Gross energy (kcal/kg)	4,022	4,038	4,064	4,087	4,074	4,053

at 25°C (12 rpm; Sheer rate 90 s⁻¹).

Statistical analysis

Broiler performance and digestibility data were analyzed as a 3×2 factorial using the General Linear Models procedure of the Statistical Analysis System (SAS, 1999) with the factors in the model consisting of type of cereal grain and level of enzyme supplementation as well as their interaction. Pen was the experimental unit. Single degree of freedom contrasts were used to compare differences between the barley control and the rye-based diets, differences between the normal and low viscosity rye and finally differences between enzyme supplemented and non-enzyme supplemented diets.

RESULTS

The results of the digestibility study are presented in Table 3. Digestibility coefficients for dry matter and crude protein were significantly ($p=0.0001$) higher for the barley-based diets than for any of the rye-based diets. Digestibility coefficients for gross energy did not differ ($p>0.05$) due to cereal grain. There were no differences in the digestibility coefficients for dry matter and gross energy between birds fed normal and low viscosity rye. However, the digestibility coefficient for crude protein was higher ($p=0.01$) for the low viscosity rye compared with the normal viscosity rye. Addition of enzyme to the diet significantly ($p=0.0001$) increased digestibility coefficients for dry matter, crude protein and energy.

The effects of enzyme supplementation and choice of

cereal grain on broiler performance during the 17 day trial are shown in Table 4. There were no significant differences in weight gain, feed intake or feed conversion between birds fed barley vs rye or between birds fed normal vs low viscosity rye. Enzyme supplementation significantly improved ($p=0.0001$) weight gain, intake and feed conversion.

DISCUSSION

The breeding program designed to reduce the viscosity of the rye was successful with the two diets formulated with the normal viscosity rye averaging 8.58 cp while the two diets formulated with the low viscosity rye averaging 4.6 cp. However, under the conditions of this experiment, no significant differences were observed for weight gain, feed intake or feed conversion between birds fed normal and low viscosity rye. In addition, no significant differences were observed in nutrient digestibility as a result of feeding ryes of differing viscosity. An earlier study conducted in our laboratory indicated that a high viscosity rye had a viscosity in excess of 18 cp (Thacker et al., 1999), indicating that both of the ryes used in the present experiment were on the low end in terms of diet viscosity. Therefore, it is possible that, had a wider range in rye viscosity been available, larger differences may have been observed in the performance of the broilers.

Regardless of the viscosity of the rye fed, supplementation with pentosanase dramatically improved broiler performance. Weight gains increased 48% for the low viscosity rye and 59% for the normal viscosity rye as a

Table 3. Main effect means showing effects of normal or low viscosity rye or barley fed with or without enzyme on nutrient digestibility for broiler chicks (1-17 days)

	Type of Cereal				Enzyme supplementation			Contrasts		
	Barley	Normal viscosity rye	Low viscosity rye	SEM ¹	No enzyme	With enzyme	SEM	Barley vs. Rye	Normal vs. Low	Enzyme vs. None
Dry matter (%)	62.2	57.4	56.5	0.76	55.1	62.3	0.62	0.0001	NS	0.0001
Crude protein (%)	53.6	48.7	45.7	0.81	44.7	53.9	0.66	0.0001	0.01	0.0001
Gross energy (%)	61.8	61.7	61.7	0.19	61.2	62.2	0.15	NS	NS	0.0001

¹Standard error of the mean.

Table 4. Interaction means showing effects of normal or low viscosity rye or barley fed with or without enzyme on nutrient digestibility for broiler chicks (1-17 days)

		Barley	Normal viscosity		SEM	P values		
			rye	rye		Cereal	Enzyme	Interaction
Dry matter (%)	No enzyme	62.9	52.7	49.6	1.08	0.0001	0.0001	0.0001
	With enzyme	61.5	62.1	63.3				
Crude protein (%)	No enzyme	54.1	43.9	36.3	1.14	0.0001	0.0001	0.0001
	With enzyme	53.1	53.5	55.2				
Gross energy (%)	No enzyme	61.9	61.0	60.9	0.27	NS	0.0002	0.005
	With enzyme	61.7	62.4	62.5				

¹ Standard error of the mean.**Table 5.** Main effect means showing effects of normal or low viscosity rye or barley fed with or without enzyme on the performance of broiler chicks (1-17 days)

	Type of cereal			SEM ¹	Enzyme			Contrasts		
	Barley	Normal viscosity rye	Low viscosity rye		No enzyme	With enzyme	SEM	Barley vs. Rye	Normal vs. Low	Enzyme vs. None
Weight gain (g)	220.5	210.9	214.5	9.60	161.4	269.2	7.84	NS	NS	0.0001
Feed intake (g)	285.5	275.7	281.8	8.40	239.9	322.0	6.86	NS	NS	0.0001
Feed conversion	1.35	1.35	1.35	0.03	1.49	1.20	0.2	NS	NS	0.0001

¹ Standard error of the mean.**Table 6.** Interaction means showing effects of enzyme supplementation on the performance of broiler chicks fed normal or low viscosity rye or barley

		Barley	Normal viscosity		SEM	P values		
			rye	rye		Cereal	Enzyme	Interaction
Weight gain (g)	No enzyme	149.3	162.9	172.1	13.57	NS	0.0001	0.10
	With enzyme	291.6	258.9	256.9				
Feed intake (g)	No enzyme	226.0	241.2	252.8	11.89	NS	0.0001	0.04
	With enzyme	344.9	310.2	310.9				
Feed conversion	No enzyme	1.52	1.49	1.47	0.044	NS	0.0001	NS
	With enzyme	1.18	1.20	1.22				

¹ Standard error of the mean.

result of enzyme supplementation. The improvements in growth rate can be largely attributed to an increased feed intake with feed intakes increasing 23% for the low viscosity rye and 28% for the normal viscosity rye as a result of enzyme supplementation. Improvements in dry matter and crude protein digestibility could also account for a portion of the increase in growth rate with dry matter and crude protein digestibility increasing 13 and 20% respectively as a result of enzyme supplementation. Improved broiler performance as a result of enzyme supplementation has been reported previously (Fengler et al., 1988; Bedford and Classen, 1992; Teitge et al., 1991).

The results of the current experiment confirm previous research showing dramatic improvements in the performance of broiler chicks fed barley-based diets when provided with dietary enzyme (Classen et al., 1985; Classen et al., 1988; Campbell et al., 1993). Water-soluble β -glucan, found in the endosperm of the barley grain, is believed to be the predominant factor responsible for the poor performance of broilers fed barley-based diets (White et al., 1981). Soluble β -glucans can cause fairly stable viscous

conditions in the small intestine which can lead to impairment in the digestion and absorption of nutrients when birds are fed barley (Burnett, 1966). Supplementation with β -glucanase is generally thought to reduce intestinal viscosity leading to improvements in nutrient digestibility (Edney et al., 1989). However, the mechanism by which enzyme supplementation exerted its effects on broiler performance in the present trial is unclear since there were no differences in dry matter, crude protein or gross energy digestibility between birds fed enzyme supplemented or unsupplemented diet.

In conclusion, the overall results of this experiment indicate that breeding efforts towards reducing the viscosity of rye did not appreciably improve the nutritional value of rye for poultry. Rye would appear to be competitive with barley as an energy source for use in diet formulation for broilers. However, enzyme supplementation can significantly increase growth rates and lead to great improvements in feed efficiency when barley or rye based diets are fed to young broilers by increasing nutrient digestibility.

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