Production and physiological responses of broilers to the inclusion of whole grain into pelleted diets

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Summary

Pelleted diets, incorporating 20% whole or ground triticale, wheat or barley in the pellets, with or without the use of appropriate exogenous enzymes, were fed to broiler chickens and the productive performance and physiological responses were recorded.

At 42 days, the incorporation of whole cereals in the pelleted feed produced similar bodyweight responses to the use of ground cereals. Whole triticale caused an improvement in feed conversion efficiency (FCE) compared to ground triticale and was similar to when a feed enzyme was added to the ground triticale. The inclusion of whole wheat or barley into the pelleted feed produced a similar FCE to the use of the ground cereal. Enzyme addition resulted in an improved FCE when wheat was the sole cereal used in a diet.

Development of the gastro-intestinal tract was influenced by the inclusion of whole grain in the pelleted diets. Gizzard weights were increased by the incorporation of whole cereal whilst proventricular size was increased on all diets other than the wheat/sorghum basal. Fully ground diets increased the incidence of proventricular dilatation which may have deleterious effects on bird health.

Introduction

Broilers have a poor nutrient absorptive ability due to an immature gastro-intestinal tract (1). The addition of exogenous feed enzymes to broiler chicken diets to overcome putative dietary problems or to supplement the birds' immature digestive tract is now commonplace. However, responses to the addition of feed enzymes are inconsistent (2). Variability in responses may be influenced by many factors such as dietary fat type and content, gut microbial populations (2) and physical effects of different foods on gut development (3). Immaturity of the gastro-intestinal tract is not addressed by the administration of exogenous feed enzymes.

Broiler diets are almost universally ground and pelleted, however, concern is mounting over the potentially detrimental effects of finely ground grain in broiler diets on bird productivity and health. Proventricular hypertrophy was reported in broilers on compound feeds by Hill (4) and Riddell (5) linked low fibre diets with dilatation of the proventriculus and meagre gizzard development. Fine (< 1 mm) dietary fibre particle size is the predisposing factor in these conditions (6). The feeding of whole grains or grits stimulates the development of greater gizzard musculature and contractile amplitude (4). It has been claimed (7) that gizzard enlargement, resulting from the feeding of whole grains and an insoluble grit, caused a return to "normal" gizzard function. However, whole grain stimulates greater gizzard development than the feeding of coarse grit (8) which may be due to the poor retention of grit relative to whole grain in the gizzard.

Gastro-intestinal tract development may be enhanced by choice feeding with the presentation of whole grain (9). However, choice feeding may not succeed with broilers due to the limited life span and poor diet selection by inexperienced birds (7). A practical, if somewhat crude, approach to choice feeding has been highlighted (10) by an increasing trend in European broiler production for the blending of whole wheat in the compounded ration to allow for differences in requirements of individual birds.

The negative effects inherent in choice feeding may be circumvented by the inclusion of whole grain into the pelleted feed. The following experiments examine the performance and physiological development of the broiler bird when presented with a range of whole cereals incorporated into pelleted diets with or without the application of appropriate feed enzymes.

Materials and Methods

Four consecutive experiments involved commercial broilers being placed at one day old in heated, multi-deck brooders and fed to 5 days on commercial starter crumbles. From five days of age, groups of 8 birds were allocated to 8 replicate pens per treatment and fed one of two commercially formulated dietary treatments with or without the inclusion of an exogenous food enzyme and which were offered as a starter food from 5-21 d of age and as a grower food from 22-42 d of age. Three trials involved the use of either triticale, wheat or barley at 20% inclusion in a sorghum basal diet. A fourth trial used a completely wheat-based diet. The dietary treatments were identical except that the 20% cereal inclusion (or 20% of the wheat in trial 4) was included in the mix as either whole or hammermilled (6 mm diameter screen) grain. All other dietary components were finely milled. After mixing, the diets were cold pelleted through a 4 mm diameter die.

The birds were weighed 42 d of age. Food conversion efficiency (FCE; g food intake/g bodyweight gain) was determined for growing period (5-42 d). At 42 d of age, three birds, randomly selected from within each group, were slaughtered by cervical dislocation and dissected. The proventriculus and gizzard were removed and full and empty fresh weights determined. The proventriculus was scored for the presence or absence of dilatation induced on the wheat/sorghum, barley/sorghum and wheat diets. The weights of digesta contents of the duodenum, jejunum and ileum were recorded for the wheat and barley/sorghum diets.

Production data were treated by analysis of variance of a factorial, randomised block design experiment using Genstat. Gasto-intestinal organ and digesta data were analysed similarly within the GLM procedure of SAS. The proventricular dilatation scores (binary data) were analysed as a general linear model using R with the significance of treatment differences tested by comparing the change in deviance due to each treatment contrast with the critical region of the X^2_1 distribution.

The experiments were approved under Authority No. ACEC 0004 (Bartter Enterprises Limited).

Results

At 42 d bird bodyweight (Table 1) was not significantly ($P<0.05$) affected by either grain processing or enzyme addition to the diets. Feed conversion efficiency (Table 1) was improved ($P>0.05$) by inclusion of whole grain or addition of enzyme to the triticale diet but the

wheat/sorghum and barley/sorghum diets were not significantly (P<0.05) influenced. Conversely, enzyme addition alone reduced (P<0.05) FCE on the complete wheat diet.

Table 1. Bodyweight and feed conversion efficiency of broilers fed diets with altered grain processing and enzyme inclusion.

Form	Enzyme	Bodyweight (g)				Feed conversion efficiency (g/g gain)			
		Sorghum basal diet			Wheat	Sorghum basal diet			Wheat
		Triticale	Wheat	Barley	Wheat	Triticale	Wheat	Barley	Wheat
Ground	-	2508	2339	2546	2603	1.817	1.815	1.706	1.742
	+	2456	2356	2567	2635	1.765	1.778	1.685	1.708
Whole	-	2438	2309	2588	2606	1.764	1.844	1.668	1.739
	+	2519	2405	2492	2550	1.736	1.812	1.681	1.742
SED[1]	Form	39.3	41.2	31.6	26.8	0.012*	0.018	0.011	0.009
	Enzyme	39.3	41.2	31.6	26.8	0.012*	0.018	0.011	0.009*
	F x E	55.6	58.2	44.7	37.8	0.018	0.025	0.016	0.012

[1] Standard error of difference of means

The size (g/kg BW) of the gizzard (Table 2) was affected ($P < 0.05$) by the form of cereal used in the diet. The gizzard was increased in size by feeding whole rather than ground grain. Inclusion of whole grain in the pelleted feeds resulted in smaller (P<0.05) proventriculi (Table 2) except when the wheat/sorghum diet was offered. Irrespective of the latter dietary result, more (P<0.05) dilatated proventriculi (Table 2) were found when birds were given diets composed solely of ground grain. Enzyme addition did not influence (P>0.05) the incidence of proventricular dilatation nor did it affect (P>0.05) proventricular or gizzard size.

Table 2. Proventriculus (P) and gizzard (G) weights (g/kg BW) and counts of proventricular dilatation (n=24).

Form	Enzyme	Proventriculus and gizzard weights (g/kg BW)								Proventricular dilatation counts		
		Sorghum basal diet						Wheat		Sorghum basal diet		Wheat
		Triticale		Wheat		Barley		Wheat		Wheat	Barley	Wheat
		P	G	P	G	P	G	P	G			
Ground	-	4.6	11.1	4.4	12.6	4.5	12.7	5.7	11.3	10	9	18
	+	4.5	11.6	4.3	12.6	4.3	13.0	4.7	11.8	11	11	17
Whole	-	3.9	13.0	4.1	14.1	3.7	14.3	4.1	12.2	3	0	8
	+	3.9	12.2	3.8	13.8	3.7	15.0	4.0	12.7	3	0	7
SE[1]	Form	0.24*	0.49*	0.19	0.33**	0.14**	0.23**	0.29**	0.33*	0.001[2]	0.001	0.001
	Enzyme	0.24*	0.49	0.19	0.33	0.14	0.23	0.29	0.33	0.809	0.558	0.653
	F x E	0.34	0.68	0.27	0.47	0.21	0.32	0.40	0.47	0.879	0.997	0.985

[1] Standard error of least squares means [2] Pr > Chi [2]

Digesta content (g/kg BW) was greater (P<0.05) in the gizzard, lower (P<0.05) in the jejunum and similar in the duodenum and ileum of birds given the whole grain barley/sorghum diet. On the complete wheat diet digesta content of the ileum was greater (P<0.05) in the birds given the ground diet without enzyme addition but similar for the other treatment combinations. Digesta content was similar in the remaining gut sections.

Discussion

The inclusion of whole grain in pelleted feeds offered to broilers resulted in similar bodyweights at 42 d and conflicting responses in FCE. Previous data (11) indicated that a depression in starter phase performance, when some cereals are used with whole grain inclusion, may result in a reduced mortality and improved production as compensatory growth occurs in the grower phase.

The improvement in performance in the grower phase may be due to a long term digestive tract adaption to the coarse feeds. The improved FCE with enzyme addition to the triticale/sorghum and wheat diets suggest that adaptation to dietary manipulation may not be complete by 42 d although in the case of the triticale/sorghum diet, inclusion of whole grain allowed for similar performance to enzyme addition to a ground diet.

The inclusion of whole grain at 20% may not necessarily be the most appropriate level required to stimulate production or gastro-intestinal tract responses. This level was dictated by a commercially sensible rate of triticale use in trial 1. Consistency of methodology was required.

The onset of proventricular hypertrophy and dilatation may have profound implications for bird health as the condition may exacerbate bird mortality due to ascites, through occlusion of the thoracic cavity and impairment of cardio-pulmonary function (12).

The experiments reported here, and consideration of other work suggest that the inclusion of whole grain in broiler diets prior to pelleting may improve the development of the birds' gastro-intestinal function over the long term and reduce the need for exogenous feed enzymes. Inclusion of whole grain provides a simple method of tempering early growth in broilers without the inherent dangers of undernutrition or restricted feeding techniques. The benefits are magnified when bird health implications are considered.

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