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Effect of Free Access to Whole Wheat, Dietary Wheat Level and Enzyme Supplementation on Broiler Performance

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Abstract: Total 480 day old male Ross broilers were used in a 2×2×2 factorial design experiment to study the effect of free access to whole wheat, dietary wheat level and enzyme supplementation on broiler performance. The 8 treatments were consisted of with/without free access to whole wheat, 2 dietary wheat levels with/without supplementation of exogenous wheat enzyme. Every dietary treatment had 5 replicates of 12 birds each. All starter (1-21 day), grower (21-39 day) and finisher (39-44 day) diets were provided isocaloric and isonitrogenous to meet nutrient requirements of broiler chickens. Whole wheat consumption of birds was 11, 18 and 8% of starter, grower and finisher diets, respectively. Feed intake of birds was highly reduced when they had free access to whole wheat whereas dietary wheat level (25 vs 50%) and enzyme supplementation did not influence feed intake. Live body weight, carcass weight and cuts were not affected by free access to whole wheat whereas a reduction in dietary wheat level and enzyme supplementation increased live body weight and breast weight measured at 44 day of age. Free access to whole wheat or reduction in dietary wheat level improved feed conversion efficiency during each and entire period of study. Enzyme supplementation of diet improved performance when wheat inclusion level increased over 25% of diet. Economic of using free access to whole wheat strategy and inclusion of wheat in the diet depends on the trade of between reduction in feed handling costs and loss of performance in broiler production.

Key words: Free access to whole wheat, dietary wheat level, exogenous enzyme, broiler

INTRODUCTION

The price of whole wheat makes it an attractive ingredient for broiler feeds but, because of its imbalanced amino acid composition, it must be offered in different ways such as choice feeding, sequential feeding and dilution of commercial feeds (Ahmet *et al.*, 2001). Choice feeding of meat birds was typical some years ago, when it was shown that acceptable growth rates could be achieved with birds allowed simultaneous access to" balancer diets" and whole-grain cereals such as wheat (Leeson and Caston, 1993). This feeding strategy enables the broiler producers to use wheat grown on site and reduces feed cost. Furthermore, it has been shown that the inclusion of whole grain decreases proventricular dilatation and mortality related to ascites and improves broiler performance, in particular the feed conversion ratio (Jone and Taylor, 2001; Nahas and Lefrancois, 2001), which may be related to an increase in starch digestibility (Hetland *et al.*, 2002). Other benefit of wheat feeding is due to higher protein content of wheat (12-14%) as compared to corn (8.5%). As a result, less soybean meal or other protein sources has to be used in wheat-based diets to achieve a necessary protein level in the finished feed (Blair, 1997). Nevertheless, early research has indicated that using whole wheat in broiler diets has little or no negative effect on cumulative performance (McIntosh *et al.*, 1962). Karakozak and Kutlu (1999) reported that the addition of whole wheat to a diet or offering whole wheat as a choice or feeding whole wheat for 8-h a day can provide considerable reduction in feed cost for live gain, while increasing fat deposition due to excess energy intake. The antinutritive activity of wheat pentosans may be related to the increase in digesta viscosity (Choct and Annison, 1990, 1992). This increased viscosity reduces nutrient assimilation within the intestine because of the interaction between pentosans and endogenous enzymes that promotes the formation of a complex that diminishes the activity of these enzymes. Reports indicated that some wheat have a low AME content and that the utilization of energy by broilers is often poor (Rogel *et al.*, 1987).

Exogenic enzymes such as xylanases are currently added to commercial wheat-based compound feed for

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broilers in order to improve growth and feed conversion ratio. The degradation of arabinoxylans, the major Non-Starch Polysaccharide (NSP) fraction in wheat, results in a reduction of digesta viscosity. Non-starch polysaccharide degrading enzymes are hypothesized to work in 2 steps, described as an ileal phase and a cecal phase (Bedford, 2000). During the ileal phase, enzymes remove fermentable substrates whereas in cecal phase, degradation products of sugars, such as xylose and xylo-oligomers are fermented by bacteria, thus stimulating the production of Volatile Fatty Acids (VFA) and the growth of specific beneficial bacteria. The presence of viscous polysaccharides increases the microbial activity in the small intestine associated with poor broiler growth performance (Wagner and Thomas, 1978; Langhout *et al*., 1999). Microbial bile acid deconjugation, leading to an impaired lipid digestion, has been suggested to be partly responsible for poor broiler performance. The purpose of this experiment was to study the effect of free access to whole wheat, dietary wheat level and enzyme supplementation on broiler performance.

MATERIALS AND METHODS

Total 480 day old male broilers were used in a 2×2×2 factorial design experiment. The 8 treatments consisted of with and without free access to whole wheat (after 16 day of age), 2 dietary wheat level (25 *vs.* 50%) with or without enzyme supplementation. The active ingredients per gram of enzyme cocktail used in this study were 1200 IU of arabinoxylase and 400 IU of glucanase (GNC Bioferm, Inc. BC. Canada). Every treatment had 5 replicates of 12 birds each. All starter (1-21 d), grower (21-39 d) and finisher (39-44 day) diets were provided isocaloric and isonitrogenous to meet the nutrient requirements based on Leeson and Summeres (2005). The chemical composition of the experimental diets is given in Table 1. Birds were kept on floor pens (1.4 m^2) covered with wheat straw. A 23:1 and 18:6 h light/dark cycles were used during 1-3 and 4-44 day of study, respectively. The birds were pen weighed at 1, 16, 21, 39 and 44 day. Feed intake was determined during 1-16, 16-21, 21-39 and 39-44 day whereas whole wheat consumption was determined during16-21, 21-39 and 39-44 day of age. Daily mortalities were weighed and recorded. Two birds with average pen weight from each replicate were sacrificed at 44 day and carcass, gizzard, breast and legs were excised and weighed. Average feed conversion rate for each pen, was calculated using pen weight gain and feed consumption corrected for mortalities. The project was reviewed and approved by the Animal Care Committee of the Ferdowsi University of Mashhad. All data were analyzed using the GLM Procedure of SAS (2000). Least significant difference was used to separate the differences between means when the F-ratio was significant ($p<0.05$).

Table 1: Composition of broiler starter, grower and finisher diets contained 25 or 50 wheat with/without enzyme supplementation

	Diet wheat level (%W) with/without enzyme supplementation (+ENZ /-ENZ)											
	Starter				Grower				Finisher			
Ingredient	25%W - ENZ	25%W +ENZ	50%W - ENZ	50%W +ENZ	25%W - ENZ	25%W +ENZ	50%W - ENZ	50%W +ENZ	25%W - ENZ	25%W +ENZ	50%W - ENZ	50%W +ENZ
Corn	35.52	35.47	12.96	12.91	41.67	41.62	19.43	19.38	49.18	49.13	27.00	27.00
Wheat	25.00	25.00	50.00	50.00	25.00	25.00	50.00	50.00	25.00	25.00	50.00	50.00
SBM 44	32.00	32.00	30.20	30.20	25.80	25.80	23.80	23.80	19.00	19.00	16.88	16.82
Alfalfa	1.50	1.50	0.50	0.50	1.50	1.50	0.50	0.50	1.50	1.50	0.50	0.50
Veg. oil	2.05	2.05	2.38	2.38	2.05	2.05	2.30	2.30	1.40	1.40	1.70	1.70
Limestone	1.75	1.75	1.87	1.87	1.80	1.80	1.87	1.87	1.80	1.80	1.87	1.87
DCP	1.15	1.15	1.08	1.08	1.05	1.05	1.00	1.00	1.01	1.01	0.97	0.97
Nacl	0.32	0.32	0.30	0.30	0.32	0.32	0.3	0.30	0.31	0.31	0.29	0.29
Meth 98	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17
Hcl Lys	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.13	0.13	0.12	0.13
Vit. Mix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Min. Mix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Enz Mix[2]	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients												
ME(Kcal kg^{-1})	29700	2970	2970	2970	3027	3025	3030	3028	3047	3045	3054	3052
CP%	20.50	20.50	20.50	20.50	18.34	18.34	18.37	18.36	16.07	16.06	16.05	16.03
Ca%	0.950	0.950	0.950	0.950	0.920	0.920	0.920	0.920	0.900	0.900	0.900	0.90
AP%	0.430	0.430	0.430	0.430	0.400	0.400	0.400	0.400	0.380	0.380	0.380	0.38
Na%	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.18
LYS%	1.200	1.200	1.200	1.200	1.020	1.020	1.020	1.020	0.900	0.900	0.900	0.90
ARG%	1.350	1.350	1.350	1.350	1.180	1.180	1.190	1.190	0.990	0.990	1.000	1.00
MET%	0.470	0.470	0.470	0.470	0.450	0.450	0.440	0.440	0.430	0.430	0.420	0.42
MET+CYS%	0.760	0.760	0.760	0.760	0.700	0.700	0.700	0.700	0.650	0.650	0.650	0.65

[1]Provided per kg of diet: vitamin A, 8000 IU; vitamin D3, 1700 IU; vitamin E, 12.0 mg; riboflavin, 9.0 mg; pantothenic acid, 12 mg; vitamin B12, 15 µg; niacin, 25 mg; choline, 1100 mg; vitamin K, 1.5 mg; biotin, 25 mg; antioxidant, 125 mg; manganese, 60 mg; zinc, 55 mg; Iron, 30 mg; copper, 6.0 mg and selenium, 0.1 mg, [2]Containing the active ingredient per gram: â glucanase, 400 IU; arabinoxylase, 1200 IU. GNC Bioferm Inc., BC. Canada

RESULTS

The effect of free access to whole wheat, dietary wheat level and enzyme supplementation on feed intake and whole wheat consumption are shown in Table 2. The intake of compound diet was significantly ($p<0.05$) lower in birds had free access to whole wheat as compared to those with no access. Dietary wheat level at the rate of 25 vs 50% did not affect feed intake of birds during each and whole experimental period. The enzyme supplementation of diet had only a significant ($p\geq0.05$) effect on feed intake when fed the starter (1-21 day) diet. Dietary wheat level did not have a significant ($p>0.05$) effect on whole wheat intake of birds when they had free access to whole wheat up to 39 day of age. Whereas the birds fed diet contained 50% wheat ate significantly less ($p<0.05$) whole wheat as compared to those fed diet contained 25% wheat during the finishing period (10.3 vs 18.6 g/b/d) and/or entire experimental period (12 vs 19 g/b/d). Enzyme supplementation of compound diet did not significantly ($p>0.05$) affect the whole wheat intake of birds with free access to whole wheat during the experimental periods.

The live body weight of chicks that had or had not free access to choice of whole wheat was not significantly ($p>0.05$) affected when weighed at 21, 39 and/or 44 day of age (Table 3). Birds fed diet supplemented with enzyme or contained less wheat (25 vs 50%) were significantly heavier than those fed diet without supplementation of enzyme or contained higher wheat level when weighed at 21, 39 or 44 day of age.

The average FCR with regard to the compound diet in birds had free access to whole wheat were significantly lower ($p<0.05$) than those with no free access to whole wheat when measured during 16-21, 21-39, 21-44 and/or 1-44 day with the exception of 39-44 and 1-21 day of age (Table 3). The FCR for birds with or without free access to whole wheat were 1.78 and 2.04, respectively for the duration of trial. The enzyme supplementation of diet did not significantly influence the FCR of birds during every period of experiment whereas the inclusion of 25 vs 50% wheat in diet of broilers significantly lowered ($p<0.05$) the FCR (1.84 vs 1.98) when calculated for the entire period of study.

Carcass weight as a percent of live weight, abdominal fat pad (g/b) and gizzard weight (g/b) were not significantly ($p>0.05$) influenced by free access to whole wheat, enzyme supplementation of diet and/or dietary wheat level (Table 4). The skinless breast with bone was not differed when birds had or had not free access to whole wheat. The enzyme supplementation of compound diet and low dietary wheat level (25 vs 50%) significantly

Table 2: Effect of access to choice of whole wheat (FWW), dietary wheat level (DWL) and enzyme supplementation (ENZ + or -) on feed and whole wheat intake*

	Feed intake (g /b/d)						
Main effect	1-16 day	16-21 day	21-39 day	39-44 day	1-21 day	21-44 day	1-44 day
FWW							
+	26.40	58.600	100.500	160.700	34.00	113.600	75.600
-	26.30	63.600	118.200	186.400	35.20	133.000	86.300
SE	0.38	1.040	1.490	3.380	0.45	1.720	0.920
P	0.85	0.001	0.001	0.001	0.08	0.001	0.001
DWL							
25%	26.30	60.100	108.600	171.000	34.40	122.100	80.30
50%	26.30	62.000	110.100	176.100	34.80	124.400	81.70
SE	0.38	1.040	1.490	3.380	0.45	1.720	0.92
P	0.98	0.190	0.490	0.280	0.51	0.350	0.28
ENZ							
+	26.80	62.300	111.000	174.700	35.20	124.90	82.10
-	25.90	59.900	107.600	174.400	34.00	121.70	79.80
SE	0.38	1.040	1.490	3.380	0.45	1.72	0.92
P	0.11	0.110	0.110	0.630	0.05	0.19	0.08
Whole wheat intake (g/b/d)							
		16-21 day	21-39 day	39-44 day	16-44 day		
DWL							
	25%	6.80	19.20	18.60	18.80		
	50%	6.30	19.90	10.30	12.00		
	SE	1.98	2.29	2.24	2.00		
	P	0.87	0.84	0.02	0.03		
ENZ							
	+	5.80	19.90	16.80	16.80		
	-	7.30	19.20	16.60	13.90		
	SE	1.98	2.29	2.24	2.00		
	P	0.59	0.84	0.29	0.31		

*None of the interactions (WWF×ENZ, WWF×DWL, ENZ×DWL and WWF×ENZ×DWL) were significant

Table 3: Effect of access to choice of Whole Wheat (FWW), Dietary Wheat Level (DWL) and Enzyme supplementation (ENZ + or -) on live body weight and feed conversion ratio*

	Live body weight (g/b)				
Main effect	1 day	16 day	21 day	39 day	44 day
FWW					
+	42.50	300.20	460.30	1499.8	1909.900
-	42.20	288.20	454.00	1520.7	1913.800
SE	0.12	5.32	9.87	20.48	26.650
P	0.17	0.12	0.65	0.47	0.920
DWL					
25%	42.50	298.60	472.30	1543.5	1961.500
50%	42.30	289.80	442.00	1477.0	1862.200
SE	0.12	5.32	9.87	20.48	26.650
P	0.28	0.25	0.04	0.03	0.010
ENZ					
+	42.30	298.50	474.60	1554.8	1981.000
-	42.50	289.90	439.70	1465.7	1842.700
SE	0.12	5.32	9.87	20.48	26.650
P	0.19	0.26	0.02	0.004	0.001

Feed conversion ratio** (g feed/g gain)	1-16 day	16-21 day	21-39 day	39-44 day	1-21 day	21-44 day	1-44day
FWW							
+	1.63	1.740	1.750	2.01	1.74	1.810	1.78
-	1.67	1.880	1.990	2.11	1.81	2.020	2.04
SE	0.12	0.030	0.020	0.06	0.05	0.030	0.03
P	0.32	0.005	0.001	0.26	0.39	0.001	0.001
DWL							
25%	1.61	1.730	1.820	1.99	1.69	1.890	1.84
50%	1.69	1.880	1.910	2.12	1.89	1.970	1.98
SE	0.02	0.030	0.020	0.06	0.05	0.030	0.03
P	0.04	0.004	0.020	0.14	0.02	0.020	0.002
ENZ							
+	1.67	1.780	1.850	1.99	1.72	1.880	1.87
-	1.63	1.840	1.880	2.13	1.83	1.950	1.98
SE	0.12	0.030	0.020	0.06	0.05	0.030	0.04
P	0.27	0.180	0.340	0.11	0.11	0.120	0.13

*Only WWF×ENZ interaction was significant for live body weight and feed conversion ratio at 16 and 1-16 day of age, respectively, ** Whole wheat intake was not included for feed conversion ratio determination

Table 4: Effect of free choice of Whole Wheat (FWW), Dietary Wheat Level (DWL) and Enzyme supplementation (ENZ + or -) on carcass cuts of birds slaughtered at 44 day of age

Main effect	LBW(g)	Carcass(g)	AF[1] (G)	Gizzard(g)	Breast[2](g)	Wholeleg[3](g)
FWW						
+	1959.50	60.7	3.48	2.67	31.9	32.2
-	1891.50	61.9	3.53	2.45	32.3	30.5
SE	54.83	0.59	0.18	0.10	0.74	0.82
P	0.38	0.16	0.84	0.13	0.64	0.16
DWL						
25%	1972.80	61.3	3.36	2.57	32.9	31.1
50%	1878.30	61.3	3.65	2.55	31.3	31.6
SE	54.83	0.59	0.18	0.10	0.74	0.82
P	0.23	0.99	0.25	0.91	0.01	0.70
ENZ						
+	1951.30	61.4	3.33	2.46	33.1	31.7
-	1899.80	61.2	3.69	2.66	31.1	31.0
SE	54.83	0.59	0.18	0.10	0.74	0.82
P	0.51	0.80	0.17	0.17	0.05	0.55

[1]Abdominal fat pad, [2]Skinless breast with bone, [3]Skinless drumstick and thigh of both legs

increased breast weight as compared to those fed diet with no enzyme supplementation or fed diet with higher wheat level. The weight of skinless whole legs (drumstick and thigh of both legs) was not significantly (p>0.05) different in birds had or had not free access to whole wheat or fed diets with different wheat levels and/or with/without enzyme supplementation.

Percent of mortality was not significantly different (p>0.05) between all treatments and was about 4.5% for the whole flock during the 44 day experiment.

DISCUSSION

Choice of access to whole wheat for broiler chickens was a conventional method some decades ago, when that acceptable growth rates could be achieved allowing simultaneous access to compound diets and whole wheat (Cowan and Michie, 1977). In northern Europe the feeding of whole wheat as a supplement to a compound feed for broilers has been a practice for the past two decades. Leeson and Caston (1993) reported that offering whole wheat as a choice after 7 day had no effect on feed intake, feed efficiency and carcass cuts but reduced carcass yield of meat birds. In their trial broilers voluntarily consumed 16.3% of diet as whole wheat up to 21 day and almost 40% of diet as whole wheat after 21 day. In contrast in the present study when the birds had access to whole wheat after 16 day of age, their whole wheat consumption was about 11 and 18% of starter and grower diets, respectively regardless of wheat content of compound diet whereas it was 11 and 6% when finisher diets contained 25 and 50% wheat, respectively. The lower whole wheat consumption (as percent of compound diet) during the starting and growing periods in our experiment as compared to those found in other trials might be due to the effect of age to offer the choice of whole wheat (16 vs 7 day), or the confounding effect of age to offer whole wheat and the level of wheat in the finisher diet during the finishing period. The compound feed intake was reduced when birds had access to whole wheat during 16-21, 21-39 and 39-44 day of age, although birds compensated their intake through consuming whole wheat in the amount of 6.5 g, 19 g and 14 g/b/d during the same periods, respectively. The live body weight was not affected by access to whole wheat whereas the feed conversion ratio without considering the whole wheat consumption was lower when birds had free access to whole wheat as compared to those fed only the compound diet during every period. The improved FCR of birds with free access to whole wheat was due to whole wheat that birds consumed during these periods and was not included to calculate the FCR. The economic of using whole wheat as a supplement to compound diet depends on the price of whole wheat, its handling cost, cost of compound diet, expected FCR and whole wheat consumption during every period. Access to whole wheat in our experiment did not influence the carcass weight, abdominal fat pad, gizzard weight, skinless breast with bone and whole legs weight whereas the carcass weight at 49 day was reduced in other reports (Leeson and Caston, 1993). It is possible that in their trial the birds had free access to whole wheat had lower nutrient intakes since similar total quantities of feed and whole wheat consumed across control, compound diet mixed with wheat and/or compound diet with access to whole wheat. The carcass weight was not different when birds had access to whole wheat after 16 day of age. In contrast smaller carcasses were observed at 49 day when birds of other studies had access to whole wheat after 7 day of age (Leeson and Caston, 1993). These discrepancies may be related to birds consumed large amount of whole wheat as compared to our trial (40 vs 15% of compound diet). Most cereal choice feeding studies have involved a compound diet less its major cereal vs. the cereal free choice. Leeson and Caston (1993) offered chicks a major grain of compound diet as choice feed. This by itself imposes some problems, as the birds continued to select more cereal the intake of critical nutrients are reduced. However, the total nutriet intakes from compound diet and whole wheat still might be sufficient for growth if the whole wheat intake is low (less than 15% in our study). The low whole wheat intake (15% of compound diet) may explain that bird nutrient intakes were probably sufficient for their overall growth. At the same time, the carcass weight and breast yield might be reduced if the nutrient intakes (in particular methionine and lysine) are not adequate for growth of birds.

The inclusion of 50% wheat in starter, grower and finisher diets of broilers suppressed live body weight and FCR of birds as compared to those fed diets contained 25% wheat, although feed intake was not affected by the level of wheat inclusion. These results were in agreement with other studies (Choct and Annison, 1990, 1992). In contrast, other reports have indicated that using wheat in broiler diets had little or no effect on cumulative performance (Wiseman and Inborr, 1990). In the present study, carcass weight and cuts were not influenced by the level of wheat in diet when measured at 44 day of age. The level of wheat (25 vs 50%) in the compound diet did not influence carcass weight or carcass cuts and this revealed that birds had received sufficient amount of nutrients during the entire trial. Other reports indicated that wheat content in broiler diets resulted in equal or even better performance when compared with a conventional corn-soybean diet (Hetland *et al.*, 2002). In our study, feed intake or whole wheat consumption were not affected by enzyme supplementation, but live body weight and breast weight were highly increased when diet was supplemented with enzyme. It appears that the inclusion of 25% wheat had less effect on the activity of endogenous enzymes and thus bird performed superior to those fed diets contained 50% wheat. The antinutritive activity of pentosans in wheat is related to the increase in digesta viscosity. The increased viscosity reduces nutrient hydrolysis within the intestine because of interaction between pentosans and endogenous enzymes that promotes formation of complex and diminishes the activity of these enzymes. However, the dietary wheat level, cultivars, growing conditions, stage of ripeness at harvest and storage condition affect the formation of pentosans endogenous enzyme complex and performance of birds and these might be the sources of incomparable results obtained in various studies. Percent of mortality was about 4.5% for the entire trial and was not influenced by free access to whole wheat, dietary wheat level and/or enzyme supplementation. Other researchers revealed no effect on mortalities when birds had free access to whole wheat (Leeson and Caston, 1993) whereas a lower mortality particularly from ascites was reported in some other studies when birds had access to whole wheat (Karakozak and Kutlu, 1999). Enzyme supplementation of diets in birds had access to whole wheat resulted in an increase in feed intake is probably due to a reduction in digesta viscosity, as reported by Pettersson *et al.* (1991). Supplementation of wheat-based diet with pentosanase enzyme (s) has shown to improve performance of poultry (Jansman *et al.*, 1999) by degrading xylan-rich polysaccharides and improving the digestion and absorption of nutrients, such as energy (Mathlouthi *et al.*, 1999), protein (Oloffs *et al.*, 1999) and fats (Francesch *et al.*, 1999).

Feeding whole wheat increased gizzard weight numerically whereas other researchers have demonstrated a significant increase in gizzard weight of chickens and turkeys that had access to whole grain (Svihus *et al.*, 1997; Bennett *et al.*, 2002). The smaller increase in gizzard weight in our experiment is probably due to low whole wheat consumption as compared to other reports. The need to increase gizzard weight in response to whole wheat may explain the adjustment period observed in growth rate and FCR as birds were introduced to higher intake of whole wheat.

CONCLUSION

Free access to whole wheat starting at 16 day of age reduces feed conversion of compound diet, but does not influence live body weight at 44 day. Carcass weight and parts does not change if the whole wheat intake is less than 15% of compound diet and offered after 16 day of age. The economic of free access to whole wheat depends on the handling and milling cost of whole wheat and cost of compound diet. Higher inclusion of wheat (50 vs 25%) in compound diet lowered whole wheat consumption and increases the FCR values. Enzyme supplementation of wheat based diet increased live body weight and improved FCR, but did not influence the carcass weight and parts. In general, increase in dietary wheat inclusion or access to whole wheat, appears to result in at least a temporary loss of growth or feed efficiency. Producers interested to add large quantities of whole wheat on farm to reduce trucking and milling costs need to consider the trade-off between lost performance and reduced feed handling costs.

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REFERENCES

Ahmet ahin, Hakan Yýldýrým, erafettin Kaya, Sibel Cano, ullarý and Mikail Baylan, 2001. Selection of whole wheat by broiler chickens in semi commercial experimental conditions, Hayvansal Üretim, 42: 8-20.

Bedford, M.R., 2000. Removal of antibiotic growth promoters from poultry diets: Implications and strategies to minimize subsequent problems. Worlds Poult. Sci. J., 56: 347-365.

Bennett, C.D., H.L. Classen and C. Riddell, 2002. Feeding broiler chickens wheat and barley diets containing whole, ground and pelleted grain. Poult. Sci., 81: 995-1003.

Blair, R., 1997. Wheat as a replacement for corn in poultry diets. Department of Animal Science, the University of British Columbia, Vancouver, B.C., Canada V6T1Z4.

Choct, M. and G. Annison, 1990. Anti-nutritional activity of wheat pentosans in broiler diets. Br. Poult. Sci., 31: 811-822.

Choct, M. and G. Annison, 1992. The inhibition of nutrient digestion by wheat pentosans. Br. Poult. Sci., 67: 123-132.

Cowan, P.J. and W. Michie, 1977. Environmental temperature and choice feeding of the broiler. Br. J. Nutr., 40: 311-315.

Francesch, M., S. Perez-Moya, I. Bodiola and J. Brufau, 1999b. Effects of cereal and feed enzyme on water consumption, dietary metabolizable energy and nutrient digestibility in broiler chickens. In: Proceedings of the 12th European Symposium on Poultry Nutrition, Veldhoven, The Netherlands. WPSA-Dutch Branch, Veldhoven, The Netherlands, pp: 258.

Hetland, H., B. Svihus and V. Olaisen, 2002. Effect of feeding whole cereals on performance, starch digestibility and duodenal particle size distribution in broiler chickens. Br. Poult. Sci., 43: 416-423.

Jansman, A.J.M., R.P.M. Bremmers and Rutkowski , 1999. Effect of enzyme supplementation of a wheat and barley based diet on broiler chick performance. In: Proceedings of the 12th European Symposium on Poultry Nutrition. Veldhoven, The Netherlands. WPSA-Dutch Branch, Veldhoven, The Netherlands, pp: 263.

Jones, G.P.D. and R.D. Taylor, 2001. The incorporation of whole grain into pelleted broiler chicken diets: Production and physiological responses. Br. Poult. Sci., 42: 477-483.

Karakozak, E. and H.R. Kutlu, 1999. Effects of whole wheat feeding and its application methods on broiler performance. Uluslararasý Hayvancýlýk'99 Kongresi, Eylül 1999-Ýzmir, pp: 21-24.

Langhout, D.J., J.B. Schutte, P. Van Leeuwen, J. Wiebenga and S. Tamminga, 1999. Effect of high- and low-methylated citrus pectin on the activity of the ileal microflora and morphology of the small intestinal wall of broiler chicks. Br. Poult. Sci., 40: 340-347.

Leeson, S. and L.J. Caston, 1993. Production and carcass yield of broilers using free-choice cereal feeding. J. Applied Poult. Res., 2: 253-258.

Leeson, S. and J.D. Summers, 2005. Commercial Poultry Nutrition. 3rd Edn. University Books, Guelph, Ontario, Canada.

Mathlouthi, N., M. Larbier and M. Lessire, 1999. Effect of xylanase supplementation on laying hen performances. In: Proceedings of the 12th European Symposium on Poultry Nutrition, Veldhoven, The Netherlands. WPSA Dutch Branch, Veldhoven, The Netherlands, pp: 268.

McIntosh, J.I., S.J. Slinger, I.R. Sibbald and G.C. Ashton, 1962. The effects of three physical forms of wheat on the weight gains and feed efficiencies of pullets from hatching to fifteen weeks of age. Poult. Sci., 41: 438-444.

Nahas, J. and M.R. Lefrancois, 2001. Effects of feeding locally grown whole barley with or without enzyme addition and whole wheat on broiler performance and carcass traits, Poult. Sci., 80: 195-202.

Oloffs, K., E. Samli and H. Jeroch, 1999. Effect of supplementation of Non-Starch-Polysaccharide (NSP) hydrolysing enzymes and wheat variety on prececal and faecal digestibility as well as metabolizable energy of laying hens. In Proceedings of the 12th European Symposium on Poultry Nutrition, Veldhoven, The Netherlands. WPSA-Dutch Branch, Veldhoven, The Netherlands, pp: 256.

Pettersson, D., H. Graham and P.A. Man, 1991. The nutritive value for broiler chickens of pelleting and enzyme supplementation of a diet containing barley, wheat and rye. Anim. Feed Sci. Technol., 33: 1-14.

Rogel, A.M., E.F. Annison, W.L. Bryden and D. Balnave, 1987. The digestion of wheat starch in broiler chickens. Aust. J. Agric. Res., 38: 639-649.

SAS Institute, 2000. SAS User's Guide: Statistics. 9th Edn. SAS Institute Inc., Cary, NC.

Svihus, B., O. Herstad, C.W. Newman and R.K. Newman, 1997. Comparison of performance and intestinal characteristics of broiler chickens fed on diets containing whole, rolled or ground grain. Br. Poult. Sci., 38: 524-529.

Wagner, D.D. and O.P. Thomas, 1978. Influence of diets containing rye or pectin on the intestinal flora of chicks. Poult. Sci., 57: 971-975.

Wiseman, J. and J. Inborr, 1990. The nutritive value of wheat and its effect on broiler performance. In: Recent Advances in Animal Nutrition. Haresign, W. and D.J.A. Cole (Eds.). Butterworths, London, UK, pp: 79-102.