Growth response of broiler chickens to finisher diets containing high amounts of wheat bran

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SUMMARY

The study investigated the effect of including high amounts of wheat bran (WB) in finisher diets on growth performance and economy of gain of broiler chickens. The WB contained g kg^{-1} of dry matter, 894.3; crude protein, 193.5; ether extract, 42.1; crude fibre, 97.1; ash, 49.5; neutral detergent fibre, 503.8; acid detergent fibre, 167.2; hemicellulose, 336.6; Lignin, 29.3; starch, 197.0; and metabolizable energy of 6.72 MJ kg^{-1}. In a feeding trial, four finisher diets containing maize, fishmeal, micro-ingredients and either 150, 250, 350 or 450 g of WB kg^{-1} diet and designated as dietary treatments WB150, WB250, WB350 and WB450, respectively, were fed *ad libitum* to 480 3-week-old commercial broiler chickens for 35 days. Birds had free access to water. As the dietary WB content was increased from 150 to 450 g kg^{-1}, there was a significant ($P < 0.01$) increase in feed intake and a reduction in body weight gain and efficiency of feed utilization. The inclusion of high amounts of WB significantly influenced carcass dressing proportion and gizzard weight. However, there were neither health-related problems nor mortalities attributable to the amount of WB in the diet. There was a decrease in the cost of kg feed and feed cost kg^{-1} liveweight gain with increasing levels of dietary WB.

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RÉSUMÉ

DONKOH, A., ATUAHENE, C. C. & DZINEKU, M.: *La réaction en croissance de poulets de chair aux régimes d'apprêteurs contenant une grande quantité de son de blé.* L'étude enquêtait l'effet de mettre une grande quantité de son de blé (SB) dans les régimes d'apprêteurs sur le comportement de la croissance et l'économie de gain de poulets de chair. Le SB contenait des g kg^{-1} de matière sèche, 894.3; protéine brute, 193.5; extrait d'éther, 42.1; fibre brute, 97.1; cendre, 49.5; fibre détergente neutre, 503.8; fibre détergente d'acide, 167.2; hémicellulose, 336.6; lignine, 29.3; fécule, 187.0; et l'énergie pour métabolisme, de 6.72 MJ kg^{-1}. Pendant un essai d'alimentation, quatre régimes d'apprêteurs contenant le maïs, le guano de poisson, les micro-ingrédients et soit 150, 250, 350 soit 450 g de SB kg^{-1} de régime et désigné respectivement comme des traitements diététiques SB 150, SB 250, SB 350 et SB 450 étaient nourries *ad libitum* aux 480 poulets de chair commerciaux ayant l'âge de trois semaines, pour 35 jours. Les volailles avaient un accès libre à l'eau. Lorsque la quantité de SB diététique était augmentée de 150 à 450 g kg^{-1} il y avait une augmentation considérable ($P<0.01$) de la consommation de régime et une réduction en gain de poids du corps et l'efficacité d'utilisation de régime. L'inclusion de grande quantité de SB influençait considérablement la proportion de carcasse à préparer et le poids de gésier. Toutefois il n'y avait ni les problèmes liés à la santé ni les mortalités attribuables à la quantité de SB dans le régime. Il y avait une réduction du coût de kg de régime et du coût de régime kg^{-1} de gain de poids vif à la fois avec l'augmentation des niveaux de SB diététique.

Introduction

The survival of the poultry industry in the future will, undoubtedly, depend on the ability of poultry to compete with humans for the available food supply. Cereal demands for direct human use is expected to increase as more than half of the human race is undernourished and the world population is still increasing. Clearly, the future of feeding poultry on high-quality feedstuffs will be increasingly questioned. Attention should,

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therefore, be given to the ability of poultry to use alternative, cheaper energy and protein feedstuffs which are unacceptable to man. Such feedstuffs include fibrous cereal by-products such as wheat bran. These by-products have limitations to their use, especially in their crude fibre content in monogastric animal feed.

Fibre comprises a complex variety of chemical compounds which are not digested by the endogenous secretions of the digestive tract of non-ruminants. Dierrick *et al.* (1989) noted that besides the positive contribution of fibre fermentation in the hindgut to energy supply in non-ruminants, considerable and mainly negative effects of dietary fibre on the use of other components of the diet, with subsequent effect on performance, cannot be ignored. Sikka (1990), however, reported that as animals become older, they adapt to high-fibre diets and digest them better. In addition, although diets high in fibre can limit energy intake (Lee, Gulliver & Morris, 1971), bulky diets may be appropriate in the tropics where food (and energy) requirements are low. This is a consequence of high ambient temperatures (Howlinder & Rose, 1989; Leenstra & Cahaner, 1991; Eberhart & Washburn, 1993). Moreover, the nature and composition of fibre depend on its source and the effect of such variations warrant further study.

This study, therefore, aimed at characterizing the fibre contained in WB, and also at determining the effects of incorporating high amounts of WB, a fibrous by-product, in broiler finisher diets on performance and economy of gain. Because there is a growing use of wheat bran and other fibrous by-products particularly in developing countries, this study is important for practical purposes, to maximize their use in poultry.

Materials and methods

Source of wheat bran

The wheat bran used in the study was obtained from Takoradi Flour Mills, Takoradi, Ghana, as a by-product of the manufacture of wheat flour.

Animals, housing and management

Commercial broiler chicks were used in the study and were maintained in deep litter pens each measuring about 2.5 × 2.0 m^2. A starter diet, containing 230 g crude protein kg^{-1} diet and ME of 12.56 MJ kg^{-1} was fed for the first 21 days. Birds had free access to feed and water. At 21 days of age (before the start of the feeding trial), the birds were weighed and those approximating most closely to the mean were selected. Four hundred and eighty birds were selected and randomly divided into four triplicate groups of 40 chicks per replicate, in a completely randomized design.

Dietary treatments

The study was conducted for 35 days (3 - 8 weeks of age), and during this period each group of 120 birds received one of the four experimental diets. Four diets were formulated with WB constituting 150, 250, 350 and 450 g kg^{-1} diet and designated as dietary treatments WB150, WB250, WB350 and WB450, respectively. Table I shows the composition of the diets fed. The experimental diets were formulated to be isonitrogenous, but differed in ME content. Birds had free access to feed and water throughout the experimental period.

Chemical analyses

The standard procedures of AOAC(1990) were used to carry out proximate analyses of WB and diets (dry matter, crude protein, ether extract, ash and crude fibre). The methods outlined by Georing & van Soest (1970) were used to analyze samples of WB for neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin, and hemicellulose. Starch content of WB was measured by the acid hydrolysis technique of Kartchner & Theurer (1981). The metabolizable energy of WB was determined by the chromic oxide indicator method (Hill *et al.,* 1960) using glucose as the reference standard and correcting for nitrogen retention. The ME values of the experimental diets were, however, calculated from values given by NRC (1994) and the determined ME content of WB.

TABLE 1

Composition of Diets Fed to 21-Day-Old Broiler Chickens

	Dietary treatments			
Ingredients (g kg^{-1})	*WB150*	*WB250*	*WB350*	*WB450*
Composition of diets				
Maize	610.0	525.0	440.0	360.0
Wheat bran	150.0	250.0	350.0	450.0
Fishmeal (63 % CP)	160.0	145.0	130.0	110.0.
Cottonseed meal	40.0	40.0	40.0	40.0
Soyabean meal	10.0	10.0	10.0	10.0
Oyster shell	20.0	20.0	20.0	20.0
Vitamin and mineral premix[a]	5.0	5.0	5.0	5.0
Salt (NaCl)	5.0	5.0	5.0	5.0
Chemical analysis				
Crude protein	206.7	209.0	208.6	206.9
Crude fibre	34.8	42.6	50.2	57.9
Ether extract	38.2	38.5	38.6	38.9
Lysine	11.0	10.6	10.3	9.7
Methionine	4.9	4.9	4.3	3.9
Calcium	14.0	13.6	13.1	12.5
Phosphorus	7.8	8.3	8.9	9.3
ME (MJ kg^{-1})[b]	11.68	11.01	10.33	9.66

[a] Premix supplied (kg^{-1} diet): vitamin A, 10 000 IU; vitamin D_3, 2 000 IU; vitamin E, 10 IU; vitamin K, 3 mg; riboflavin, 2.5 g; cobalamin, 0.05 mg; pantothenic acid, 5 mg; niacin, 12.5 mg; choline, 175 mg; folic acid, 0.5 mg; Mg, 2.8 mg; Fe, 0.5 mg; Cu, 50 mg; Zn, 25 mg; Co, 62.5 mg

[b] Calculated from data of NRC (1994) and the estimated metabolizable energy value of wheat bran

Parameters measured

Broiler growth performance was assessed weekly by measuring body weight gain, feed intake, and feed conversion efficiency (feed : weight gain). Mortality was checked twice daily. Birds that died were weighed for adjustment of feed use. After the experimental period, four broilers (two males and two females) per replicate were randomly selected and starved of feed for about 18 h to empty their crops. The chickens were individually weighed, slaughtered, defeathered, and eviscerated. Carcass dressing proportion was calculated from eviscerated weight and liveweight. Other carcass parameters measured included weight of blood, feathers, viscera, liver and gizzard, all expressed as g kg^{-1} body weight.

Economics of production was based on the feed cost per kg diet and feed cost per kg weight gain. Feed cost per kg for each of the experimental diets was estimated based on the prices of the ingredients at the time of the trial. Feed cost per kg liveweight gain was also calculated for individual dietary treatments.

Statistical analysis

The general linear models procedure of SAS (1987) was used to analyze the dietary treatment effects for all the variables measured.

Results and discussion

Chemical composition

Table 2 shows the chemical analyses of WB. The estimated ME value (6.72 MJ kg^{-1} DM) reported here for WB is relatively higher than the values of 5.26 and 5.44 MJ kg^{-1} presented by Allen (1989) and NRC (1994), respectively. The differences in the composition of WB indicate the variable nature of this by-product. Bath *et al.* (1989) attributed the variation in composition of many feedstuffs to differences in climate, soil conditions, maturity, variety, management, and processing factors.

In comparison with values for maize by Allen (1989), WB contained more protein, ether extract, fibre and ash, but less of metabolizable energy. According to Schulze *et al.* (1994), the neutral detergent fibre of WB consisted of about 69 per cent hemicellulose, 25 per cent cellulose, and 6 per cent lignin. The value for lignin in this study indicates that WB is not a heavily lignified fibre source. The lignin content averaged 29.3 g kg^{-1} DM which is relatively lower than the value 38.6 g kg^{-1} DM reported by Champ *et al.* (1989). Further confirmation of low levels of lignin in WB is provided by Dierrick *et al.* (1989) who characterized WB as not too heavily lignified fibre source.

TABLE 2

Chemical Composition of Wheat Bran[a]

Composition	*Dry matter (g kg^{-1})*
Dry matter	894.3
Crude protein	193.5
Ether extract	42.1
Crude fibre	97.1
Ash	49.5
Neutral detergent fibre	503.8
Acid detergent	167.2
Hemicellulose	336.6
Lignin	29.3
Starch	187.0
Metabolisable energy (MJ kg^{-1})[b]	6.72

[a]The values are the means of four samples

[b]Estimated according to the method of Hill *et al.* (1960)

The starch content in the WB used in this study was 187 g kg^{-1} DM. This shows that the product contained an appreciable quantity of wheat endosperm. Graham, Hesselman & Aman (1986) and Schulze *et al.* (1994) used wheat bran that contained 156 and 179 g of starch kg^{-1} DM, respectively. Graham, Hesselman & Aman (1986) also indicated that the soluble fraction of the non-starch polysaccharides in the WB was only 7 per cent. The fibre fraction in the diets used in this study, therefore, can be considered as mainly insoluble.

Broiler feeding trial

Table 3 shows the general performance of the experimental population. The different dietary treatments containing different amounts of WB exerted significant ($P< 0.01$) effect on the total feed intake per bird. Total feed intake for the 5-week experimental period ranged from 3.38 to 3.94 kg. Regression of feed intake against level of WB in diets yielded the following equation:

Y (feed intake) = 3.10 + 0.02 X ($r = 0.99; P < 0.01$),

where X is the level of WB in the diet.

It has been reported that birds fed high-fibre diets during the growing period increased their consumption to compensate for the lower nutrient levels, especially energy in the diet which mainly determines feed consumption in broiler chickens (Donkoh *et al.,* 1991). Crude fibre acts as an energy diluent; thus, the amount of each diet consumed depended on its caloric density (Scott, Nesheim & Young, 1982), and the inclusion of different amounts of WB, as expected, caused increased feed consumption.

Table 3 shows data relating to initial 3-week-old body weight, total weight gain, and efficiency of feed use. The average chick weight after selection at 3 weeks of age for birds reared under dietary treatments WB150, WB250, WB350, and

TABLE 3

Effect of Wheat Bran on the Performance, Carcass Characteristics, and Economy of Gain of Broiler Chickens Over the Period from 21 to 56 Days of Age

Response criteria	*Dietary treatments*					
	WB150	*WB250*	*WB350*	*WB450*	*EM*	*r*
Feed intake (kg)	3.38^{a}	3.57^{b}	3.79^{c}	3.94^{d}	0.106	0.99
Protein intake (g)	689.65^{a}	746.13^{b}	790.59^{c}	815.19^{d}	22.24	0.99
ME intake (MJ)	39.48^{a}	39.31^{ab}	39.15^{b}	38.06^{c}	0.280	-0.89
Initial 3-week body weight (g)	542.50	543.20	542.80	543.00		
Weight gain (kg)	1.48^{a}	1.40^{b}	1.34^{c}	1.23^{d}	0.046	-0.99
Feed conversion ratio	2.28^{a}	2.55^{b}	2.83^{c}	3.20^{d}	0.171	0.99
Mortality (%)	0.83^{a}	0.00^{a}	0.83a	0.83^{a}	0.180	0.26
Dressing proportion (g kg^{-1})	759.00^{a}	754.00^{a}	746.00^{b}	734.00^{c}	4.720	-0.98
Blood (g kg^{-1})	36.20^{a}	35.70^{a}	35.90^{a}	36.10^{a}	0.096	-0.06
Feathers (g kg^{-1})	54.50^{a}	56.40^{a}	55.20^{a}	55.80^{a}	0.352	0.43
Viscera (g kg^{-1})	77.70^{a}	82.10^{a}	82.50^{a}	77.80^{a}	1.139	0.03
Liver (g kg^{-1})	18.60^{a}	19.00^{a}	18.50^{a}	19.00^{a}	0.114	0.34
Gizzard (g kg^{-1})	19.00^{a}	20.10^{b}	21.30^{c}	21.66^{c}	0.529	0.97
Feed cost kg^{-1} ($)	0.29	0.25	0.21	0.17		
Feed cost kg^{-1} weight ($)	0.66	0.64	0.59	0.54		

SEM - standard error of the means
r - correlation coefficient
Means within a row showing different superscripts are significantly different

WB450 were similar. There were, however, significant differences ($P< 0.01$) in body weight gains and feed conversion efficiency during the period of 3 to 8 weeks of age. Birds on dietary treatment WB150 registered the highest weight gain and were more efficient in feed use compared with the other treatments; treatment WB450 was the least efficient. The following correlations between the level of WB in the diet and the weight gain and feed conversion efficiency of broiler chickens were found:

$$Y\,(\text{weight gain}) = 1.61 - 0.0008X\ (r = -0.99;\ P<0.01)$$

$$Y\,(\text{feed: gain}) = 1.803 + 0.03X\ (r = 0.99;\ P<0.01)$$

The reduction in weight gain and the deterioration in feed conversion efficiency with increasing level of WB might be attributed to the increasing fibre level. Several investigators (Graham, Hesselman & Aman, 1986; Fernandez & Jorgensen, 1986; Graham & Aman, 1987a,b) have reported that addition of fibre to the diet can lead to a lower apparent digestibility of starch, fat, crude protein, and minerals. Fibre may also absorb amino acids and peptide, and withhold them from absorption (Bergner, Simon & Zimmer, 1975; Sauer *et al.*, 1991). Moreover, the water-binding capacity of fibre has been reported to reduce diffusion of the products of digestion towards mucosal surface (Dierrick *et al.*, 1989). Thus, the lower growth rates and the reduced efficiency of feed use observed for birds on diets containing higher concentrations of WB might be caused by the reduced amount of protein and other nutrients available for growth, particularly when true growth is considered as deposition of protein. This defect ultimately affected the efficiency of feed conversion into tissue.

Finally, the reduced performance might also be because as the concentration of WB in the diets increased, the metabolizable energy values of the diets decreased (Table 1). Higher energy diets furnish more energy for the use of protein for growth than do lower energy diets (Dale & Fuller, 1980).

There were no health-related problems attributable to the level of WB in the diet. Also mortality did not show any consistent trend. A total of three deaths was recorded during the trial; one during the 1st week of the trial in birds under dietary treatment WB150, and two during the 2nd week of the trial, one each from the dietary treatments WB350 and WB450. Post-mortem examination indicated no specific causes for the deaths. Perhaps, the dietary treatments were not severe enough to offset any physiological or metabolic conditions that could have eventually caused death.

The level of WB in the diet produced correlation coefficients of -0.98, -0.06, 0.43, 0.03, 0.34, and 0.97 when linearly regressed against carcass dressing proportion, weight of blood, feathers, viscera, liver and gizzard, expressed as g kg^{-1} body weight. The values, with the exception of the carcass dressing proportion and weight of gizzard, were not significant ($P<0.05$), indicating that the inclusion of WB did not influence these carcass parameters. The lower carcass dressing proportion mainly reflected the significant effect on the weight gain. High fibre content of diet is known to cause thickening and enlargement of the gizzard (Kondra, Sell & Guenter, 1974; Deaton, McNaughton & Burdick, 1979). The differences in the fibre content of the diets in this study could have been high enough to significantly ($P<0.01$) influence the weight of the gizzard.

Of considerable interest to poultry producers in areas of the world where WB is available is the observation that feed cost as well as feed cost per kg liveweight gain declined as more WB was added to replace maize and fishmeal in the diet (Table 3). The diet which contained higher amounts of WB was cheaper, i.e. \$0.29, \$0.25, \$0.21, and \$0.17 per kg for dietary treatments WB150, WB250, WB350 and WB450, respectively. Feed cost per kg liveweight gain decreased from \$0.66 (WB150) to \$0.64 (WB250), \$0.59 (WB350), and \$0.54 (WB450). This was due solely to the huge price disparities between WB and the two major feed ingredients, maize and fishmeal. At the time of the trial, WB cost an average of \$0.03 per kg while maize and fishmeal cost about \$0.20 and \$0.70 per kg, respectively. This study agrees with that of Attia, Alsobayel & Bayoumi (1991) who noted that the feed cost to produce 1 kg of broiler could be minimum with low-energy diets.

It is concluded that under some price conditions, slower and less efficient gains from low-cost diets containing high amounts of WB may be more economical than fast and more efficient gains from high-cost diets based on high amounts of conventional feedstuffs such as maize and fishmeal. It is further envisaged that WB may have a wider application in diets for growing pullets and laying hens which have lower energy requirements. A wide range of dietary energy levels can be used in layer diets without affecting egg production. Levels varying from 2 400 to 3 200 kcal ME kg^{-1} have been studied extensively (Piliang *et al.*, 1982; Mannion & McCloud, 1984).

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