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Use of Natural Insoluble Fiber in Oat Hulls (*Avena sativa*) as Non-Antibiotic Growth Promoter in Broilers

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Abstract

Experiment was conducted to study effect of natural insoluble fiber in oat hulls as non-antibiotic growth promoter in 180 Cobb-400Y broiler chicks. They were randomly divided into six groups viz., A to F. Each group was further subdivided into two replicates. Groups A and B received corn-soybean based diet with and without antibiotic growth promoter (AGP), respectively. Groups C and D received diet with 2% oat hulls with and without AGP, respectively. Groups E and F received diet with 2% oat hulls with 100 Kcal reduction in ME and 2.5% reduction in CP with and without AGP, respectively. Group A recorded the highest live weight and gain in weight. The highest feed consumption was recorded by group B. The differences in FCR recorded by different groups were statistically non-significant. The differences in intestinal total viable count and coliform count of birds from different groups were statistically non-significant. Group A recorded the highest net profit per kg. Hence, it is concluded that inclusion of oat hulls results in better production performance and it could be a new area of research to replace AGPs in broiler diet.

Keywords: Broilers, Insoluble Fiber, Non-antibiotic Growth Promoter , Oat Hulls

Introduction

According to the National Office of Animal Health (NOAH, 2001), antibiotic growth promoters (AGPs) are used to help growing animals, digest their food more efficiently, get maximum benefits from it and allow them to develop into strong and healthy individuals. AGPs have been used extensively in intensive poultry operations to minimize disease and improve growth and feed utilization. However, the industry is currently evaluating alternatives to chemical therapeutics and antibiotics. There is much controversy regarding the impact of antimicrobials in animal diets on the development of resistant strains of microbes that could directly impact human health and carry over into meat and bio-products as well as the negative impacts associated with their excretion into the environment. Development of alternatives to the present in-feed antimicrobials is an exciting area of current research worldwide. Alternatives to antibiotics mainly include acidifiers, probiotics, prebiotics, herbal products, immune-modulators and also feed enzymes.

Poultry feeds usually contain a significant amount of non-starch polysaccharides (NSP), mainly derived from cell walls in the endosperm and the outer layers of seeds. Recent studies indicated that moderate amount of fiber improves gizzard function (Svihus, 2011), digestibility of non-fiber nutrients (Jim´enez-Moreno *et al.*, 2009a; Gonz´alez-Alvarado *et al.*, 2010), gastro-intestinal tract health (Kalmendal *et al*. 2011; Mateos *et al.*, 2012) and growth performance (Gonz´alez-Alvarado *et al*., 2007; Jim´enez-Moreno *et al*., 2013) in broilers. Differences in physicochemical properties of fibrous ingredients such as solubility, water holding capacity, viscosity, bulk, fermentability and ability to bind bile acids, might affect in different ways on the development of GIT and the digestibility of nutrients in non-ruminant animals (Montagne *et al.*, 2003). Many hull rich feed ingredients like barley, oats and soybean meal may contain a considerable amount of water-insoluble fiber (Bach Knudsen, 1997). Oat hulls are one of the most common feedstuffs used as livestock feed abundantly produced by oat processing industry. Also, oat hulls have significant availability of insoluble fiber. When oat hulls have been added to broiler diets, increased starch digestibility has been observed (Rogel *et al.*, 1987; Hetland and Svihus, 2001), Newcombe and Summers (1985) have also reported higher feed intake with inclusion of oat hulls in the diet. Therefore, the present experiment was designed to investigate the effects of insoluble fiber from oat hulls on gut health and performance of broilers and exploring its potential to replace antibiotic growth promoters.

Materials and Method

The experiment was conducted on 180-day old broiler chicks of 'Cobb 400Y' strain for a period of six weeks. The day-old chicks were randomly divided into six equal groups of 30 birds and each group was further divided into two replicates of 15 birds each. Diets of group A, B, C and D were isocaloric and isonitrogenous. Each group was allotted with one of the following feed treatments.

Group A: Corn-soybean diet with antibiotic growth promoter* (AGP)
Group B: Corn-soybean diet without AGP
Group C: Diet with 2% oat hulls with AGP
Group D: Diet with 2% oat hulls without AGP
Group E: Diet with 2% oat hulls with 100 Kcal reduction in ME and 2.5% reduction in CP with AGP
Group F: Diet with 2% oat hulls with 100 Kcal reduction in ME and 2.5% reduction in CP without AGP
*AGP used in this trial was Enramycin @ 100 g/T.

The daily records for feed consumption and mortality were maintained. Weekly records of live weight, gain in weight, feed consumption, feed conversion ratio and mortality were maintained. The economics of the production was calculated at the end of the trial. Six birds from each group were sacrificed at the start and at the end of the trial and the mid-intestine samples were collected for total viable count (TVC) and coliform count. The feed formulations of the diets used in the trial are presented in Table 1, 2 and 3, respectively.

Table 1: Feed formulation for prestarter diets

Ingredients (%)	Group A	Group B	Group C	Group D	Group E	Group F
Maize	53.62	53.62	50.61	50.61	54.89	54.89
Palm oil	1.91	1.91	2.44	2.44	0.23	0.23
Oat hulls	0	0	2	2	2	2
Soybean deoiled cake	40.38	40.38	40.86	40.86	38.79	38.79
Trace mineral mixture	0.1	0.1	0.1	0.1	0.1	0.1
Mono-calcium phosphate	1.4	1.4	1.41	1.41	1.41	1.41
Limestone powder	1.8	1.8	1.8	1.8	1.8	1.8
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin premix	0.02	0.02	0.02	0.02	0.02	0.02
Choline 60%	0.1	0.1	0.1	0.1	0.1	0.1
Coccidiostat	0.05	0.05	0.05	0.05	0.05	0.05
*MHA	0.16	0.16	0.16	0.16	0.16	0.16
Lysine	0.06	0.06	0.05	0.05	0.05	0.05
Toxin binder	0.1	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100	100

Table 2: Feed formulation for starter diets

Ingredients (%)	Group A	Group B	Group C	Group D	Group E	Group F
Maize	54.44	54.44	51.45	51.45	55.72	55.72
Palm oil	3.4	3.4	3.93	3.93	1.72	1.72
Oat hulls	0	0	2	2	2	2
Soybean deoiled cake	38	38	38.46	38.46	36.4	36.4
Trace mineral mixture	0.1	0.1	0.1	0.1	0.1	0.1
Mono-calcium phosphate	1.45	1.45	1.45	1.45	1.45	1.45
Limestone powder	1.8	1.8	1.8	1.8	1.8	1.8
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin premix	0.02	0.02	0.02	0.02	0.02	0.02
Choline 60%	0.1	0.1	0.1	0.1	0.1	0.1
Coccidiostat	0.05	0.05	0.05	0.05	0.05	0.05
*MHA	0.17	0.17	0.17	0.17	0.17	0.17
Lysine	0.07	0.07	0.07	0.07	0.07	0.07
Toxin binder	0.1	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100	100

Table 3: Feed formulation for finisher diets

Ingredients (%)	Group A	Group B	Group C	Group D	Group E	Group F
Maize	59.2	59.2	56.17	56.17	60.44	60.44
Palm oil	4.22	4.22	4.76	4.76	2.55	2.55
Oat hulls	0	0	2	2	2	2
Soybean deoiled cake	32.6	32.6	33.08	33.08	31	31
Trace mineral mixture	0.1	0.1	0.1	0.1	0.1	0.1
Mono-calcium phosphate	1.25	1.25	1.25	1.25	1.25	1.25
Limestone powder	1.92	1.92	1.92	1.92	1.94	1.94
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin premix	0.02	0.02	0.02	0.02	0.02	0.02
Choline 60%	0.1	0.1	0.1	0.1	0.1	0.1
Coccidiostat	0.05	0.05	0.05	0.05	0.05	0.05
*MHA	0.14	0.14	0.15	0.15	0.15	0.15
Lysine	0.1	0.1	0.1	0.1	0.1	0.1
Toxin binder	100	100	100	100	100	100
Total	59.2	59.2	56.17	56.17	60.44	60.44

**MHA=Methionine hydroxyl analog (84% methionine)*

Statistical Analysis

The data collected pertaining to all the parameters were subjected to completely randomized block design as per Snedecor and Cochran (1994).

Results and Discussions

Live Weights

The average initial and final live weight (g per bird) at the end of six weeks are represented in Table 4. The birds from group A receiving corn-soybean based diet with antibiotic growth promoter (AGP) recorded the highest average live weight at end of six weeks followed by the birds from groups B, E, D, C and F. It is observed that birds from group A recorded 0.67 % higher live weight than the birds from group B. The birds from group D recorded 0.62% higher live weight than the birds from group C. However, the birds from group D recorded 6.57% lower live weights than the birds from group B. Further, the birds from group F recorded 3.93% lower live weights as compared to birds from group E. It is also noticed that the birds from group D recorded marginally higher live weights than the birds from group F. The differences in the weekly live weights of birds from different groups were statistically non-significant (P>0.05). The inclusion of oat hull in the diet of birds resulted in comparatively lower body weight. However, the differences were statistically non-significant (P>0.05). The findings of present study are in agreement with that of Jiménez-Moreno *et al.* (2009a) who used 3% oat and González-Alvarado *et al*. (2010) who used oat hulls in diet @ 30g/kg of feed, where body weight gain was higher due to better live body weights.

Table 4: Average weekly live weights (g) of birds from different groups

Weeks	Group A	Group B	Group C	Group D	Group E	Group F
Day-old	48.23	48.9	50.3	49.47	50	49
I	146.63	154.17	149.65	150.47	148.53	141.44
II	378.82	406.6	391.98	395.17	398	359.63
III	785.94	811	780.8	802.75	785.4	734.43
IV	1331.89	1366.27	1326.21	1371.15	1343.04	1283.9
V	1977.49	1974.47	1879.13	1953.33	1903.77	1839.04
VI	2629.07	2611.57	2424.87	2439.87	2467.97	2371.1
Mean	**1042.58**	**1053.28**	**1000.42**	**1023.17**	**1013.81**	**968.36**

Table 5: ANOVA for live weights

Sources	DF	SS	MSS	F
Treatments	5	32615.13	6523.03	0.0075^{NS}
Error	36	31443384.1	873427.33	
Total	41	31475999.2		

NS=Non-significant

Gain in Weight

The average weekly gain in weight (g per bird) of birds from different groups at the end of six weeks are presented in Table 6. Group A recorded the highest average gain in weight at the end of six weeks followed by groups B, E, D, C and F. It was observed that the birds from group A recorded 0.71% higher gain in weight than birds from group B. Similarly, the birds from group E recorded 4.13% higher gain in weight than birds from group F. However, the birds from group D recorded 0.67% higher gain in weight than birds from group C. Further, the birds from group D and F recorded lower gain in weight when compared to the gain in weight of birds from group B. The statistical analysis of the data revealed that, the differences among the average weekly gain in weight of birds from different groups were statistically non-significant (P>0.05). The findings of the present study are in agreement with the findings of Hetland and Svihus (2001) where weight gain was not significantly reduced because of oat hulls inclusion. Contrary to these findings, González-Alvarado *et al.* (2007), Jiménez-Moreno *et al.* (2009b) and González-Alvarado *et al.* (2010) found higher gain in weight in broilers fed with oat hulls.

Table 6: Average weekly gain in weights (g) of birds from different groups

Weeks	Group A	Group B	Group C	Group D	Group E	Group F
I	98.4	105.27	99.35	101	98.53	92.44
II	232.19	252.43	242.33	244.71	249.47	218.2
III	407.12	404.41	388.82	407.58	387.4	374.8
IV	545.95	555.27	545.42	568.4	557.64	549.47
V	645.61	608.2	552.92	582.19	560.73	555.14
VI	651.58	637.1	545.74	486.54	564.2	532.06
Total	**2580.84**	**2562.67**	**2374.57**	**2390.4**	**2417.97**	**2322.1**
Mean	**430.14**	**427.11**	**395.76**	**398.4**	**402.99**	**387.02**

Table 7: ANOVA for gain in weights

Sources	DF	SS	MSS	F
Treatments	5	9332.82	1866.56	0.045^{NS}
Error	30	1232610.36	41087.01	
Total	35	1241943.18		

NS=Non-significant

Feed Consumption

The average weekly feed consumption per bird (g per bird) during the entire trial period for groups A to F are presented in Table 8. The highest feed consumption was recorded by the birds from group B, followed by birds from groups D, E, F, A and C. It is noticed that, birds from group B recorded 5.94 % higher feed consumption than the birds from group A. Similarly, the birds from group D consumed 4.05 % more feed than birds in group C. However, the feed consumption of birds from group E was 1.99 % higher than feed consumption of birds from group F. The statistical analysis of the data revealed that the differences among average weekly feed consumption of birds from different groups were statistically non-significant (P>0.05). The findings of the present study are in agreement with Jiménez-Moreno *et al.* (2013) where daily feed consumption was not affected when 25, 50 and 75 g/kg of oat hulls are used in the diet. Contrary to this, findings of González-Alvarado *et al.* (2010) and Hetland and Svihus (2001) found higher feed consumption in birds fed with oat hulls in diet.

Table 8: Average weekly feed consumption (g) of birds from different groups

Weeks	Group A	Group B	Group C	Group D	Group E	Group F
I	129.6	133.17	125.66	127.44	128.47	123.83
II	315.36	335.84	322.57	333.17	331.84	314.97
III	552.4	593.73	562.12	568.47	592.1	564.14
IV	892.3	930.67	881.67	893.8	922.37	899.7
V	1075.18	1116.39	1029.8	1092.22	1088.77	1066.3
VI	1156.07	1255.94	1140.43	1211.75	1147.05	1159.57
Total	**4120.9**	**4365.73**	**4062.25**	**4226.84**	**4210.59**	**4128.5**
Mean	**686.82**	**727.62**	**677.04**	**704.47**	**701.77**	**688.08**

Table 9: ANOVA for feed consumption

Sources	DF	SS	MSS	F
Treatments	5	9572.09	1914.42	0.011^{NS}
Error	30	5390194.52	179673.15	
Total	35	5399766.61		

NS=Non-significant

Feed Conversion Ratio

The feed conversion ratio of birds recorded from different groups are presented in Table 10. It is observed that the birds from group A recorded better feed conversion ratio than it's counterpart group B. Similarly, the birds from group C recorded 3.61 % better FCR than birds from group D. Moreover, the birds from group E recorded 2.40 % better FCR than birds from group F. This indicated that use of AGP is useful in improving FCR of the birds. It is also noticed that the birds from group D and F recorded marginally poor FCR than birds from group B, indicated that use of oat hulls is not beneficial for improvement in FCR. The analysis of the data revealed that the differences in FCR recorded by the birds from different groups were statistically non-significant (P>0.05). Jiménez-Moreno *et al*. (2013) reported better FCR also when birds were fed with oat hulls in diet. Hetland *et al.* (2005) also found no significant reduction in feed conversion efficiency upon use of oat hulls in diet. These findings do not corroborate with the observations of the present study.

Table 10: Average weekly feed conversion ratios of birds from different groups

Weeks	Group A	Group B	Group C	Group D	Group E	Group F
I	1.32	1.26	1.26	1.26	1.3	1.34
II	1.36	1.33	1.33	1.36	1.33	1.44
III	1.36	1.47	1.45	1.39	1.53	1.51
IV	1.63	1.68	1.62	1.57	1.65	1.64
V	1.67	1.84	1.86	1.88	1.94	1.92
VI	1.77	1.97	2.09	2.49	2.03	2.18
Mean	**1.52**	**1.59**	**1.6**	**1.66**	**1.63**	**1.67**
Cumulative	**1.6**	**1.7**	**1.71**	**1.77**	**1.74**	**1.78**

Table 11: ANOVA for feed conversion ratio

Sources	DF	SS	MSS	F
Treatments	5	0.093	0.019	0.181^{NS}
Error	30	3.152	0.105	
Total	35	3.245		

^{NS}=*Non-significant*

Mortality

It is seen that the mortality in groups A to F was 3.33, 3.33, 3.33, 3.33, 0 and 0%, respectively, which was well within the limit of 4%. Thus, it may be concluded that use of insoluble fiber in oat hulls (A*vena sativa)* as a non-antibiotic growth promoter in boilers does not have any adverse effect on the health of broiler chickens.

Total Viable Count (TVC)

From the data of total viable count represented in Table 12, it is revealed that the birds from group A recorded higher total viable count than birds from group B. However, it is observed that birds from group D recorded higher TVC than birds from group C. Similarly, birds from group F recorded higher TVC as compared to birds from group E. The analysis of the data revealed that the differences in the TVC recorded by the birds from different groups were statistically non-significant (P>0.05). However, the TVC count of intestinal content of birds at six weeks age was found significantly higher ($P \leq 0.01$) than chicks at day-old age.

Table 12: Average total viable count (log value) of birds from different group

Weeks	Group A	Group B	Group C	Group D	Group E	Group F	Mean
Day-old	4.18	3.91	3.9	3.93	3.85	3.89	3.94
Sixth week	6.97	6.43	5.89	5.95	5.75	5.99	6.16
Mean	5.58	5.17	4.89	4.94	4.8	4.94	

Table 13: ANOVA for total viable count

Sources	DF	SS	MSS	F
Readings	1	14.77138	14.77138	239.0491^{NS}
Treatments	5	0.801404	0.160281	2.593865^{NS}
Error	5	0.308961	0.061792	
Total	11	15.88175		

^{NS}=*Non-significant*

Coliform Count

From the data represented in Table 14, it is observed that higher coliform count was recorded in group A than group B. Moreover, it is observed that birds from group D recorded lower coliform count than birds from group C. However, the birds from group F recorded higher coliform count as compared to birds from group E. The analysis of the data revealed that the differences in the coliform count recorded by the birds from different groups were statistically non-significant. However, the difference in coliform count of intestinal content of day-old chicks and birds at the end of six weeks recorded significant difference ($P \leq 0.01$).

Table 14: Average coliform count (log value) of birds from different groups

Weeks	Group A	Group B	Group C	Group D	Group E	Group F	Mean
Day-old	3.72	3.72	3.69	3.67	3.69	3.66	3.69
Sixth week	7.67	7.13	5.89	5.39	5.46	5.79	6.22
Mean	5.69	5.43	4.79	4.53	4.58	4.72	

Table 15: ANOVA for coliform count

Sources	DF	SS	MSS	F
Readings	1	19.16494	19.16494	44.72087 ^{NS}
Treatments	5	2.353828	0.470766	1.098519 ^{NS}
Error	5	2.142729	0.428546	
Total	11	23.66149		

NS=Non-significant

Economics of Production

The net cost of production per bird was Rs. 159.14, 165.39, 159.09, 163.21, 157.26 and 154.63 for the birds from groups A, B, C, D, E and F, respectively. The net profit per bird was Rs.24.89, 17.42, 10.65, 7.58, 15.50, and 11.34 for groups A to F, respectively. The corresponding net profit per kg for groups A to F was Rs. 9.47, 6.67, 4.39, 3.11, 6.28 and 4.78. The birds from group A recorded highest net profit per kg followed by the birds from groups B, E, F, Cand D, respectively. It is observed that, though the cost of production of Group A was higher than other groups the weight gain for the birds from group A was also higher, recording higher profit margins.

Overall Performance

From the Table 16, it is noted that that, the birds from group A receiving all corn-soybean diet with AGP, recorded better performance with respect to live weight, gain in weight, FCR and net profit. However, the birds from group B with a similar diet without AGP showed higher feed consumption. Birds from group C, receiving 2% oat hulls with AGP showed better performance in terms of FCR and net profit as compared to birds from group D receiving similar diet without AGP. However, birds from group D recorded higher feed consumption and better live weight and gain in weight than birds from group C. Birds from group E, receiving 2% oat hulls with a reduction in 100 kcal ME and 2.5 % CP with AGP recorded higher live weight, feed consumption, net profit and better FCR than birds from group F receiving similar diet without AGP. Hence, it is concluded that birds receiving a corn-soybean diet along with AGP recorded better performance than the birds not receiving AGP in than corn-soybean diet. The birds receiving a diet containing 2% oat hulls without AGP recorded marginally better live weights and gain in weight as compared to the birds receiving the same diet with AGP. The birds receiving a diet containing 2% oat hulls along

with a reduction in 100 kcal ME and 2.5 % CP with or without AGP did not show any compensation of reduced ME and CP due to the addition of oat hulls and/or AGP.

Table 16: Overall performance of birds from different group

Parameters	Group A	Group B	Group C	Group D	Group E	Group F
Initial live weight (g)	48.23	48.9	50.3	49.47	50	49
Final live weight (g)	2629.07	2611.57	2424.87	2439.87	2467.97	2371.1
Total gain in weight (g)	2580.84	2562.67	2374.57	2390.4	2417.97	2322.1
Total feed consumption(g)	4120.9	4365.73	4062.25	4226.84	4210.59	4128.5
Feed conversion ratio	1.6	1.7	1.71	1.77	1.74	1.78
Mortality (%)	3.33	3.33	3.33	3.33	0	0
Net profit per bird (Rs.)	24.89	17.42	10.65	7.58	15.5	11.34
Net profit per kg (Rs.)	9.47	6.67	4.39	3.11	6.28	4.78

Conclusion

It can be concluded that birds receiving a corn-soybean diet along with AGP recorded better performance than the birds not receiving AGP in the corn-soybean diet. The birds receiving a diet containing 2% oat hulls without AGP recorded marginally better live weights and gain in weight as compared to the birds receiving the same diet with AGP. The birds receiving a diet containing 2% oat hulls along with a reduction in 100 kcal ME and 2.5 % CP with or without AGP did not show any compensation of reduced ME and CP due to the addition of oat hulls and/or AGP. It may be concluded that inclusion of insoluble fiber in the diet could be a new research area to replace AGPs used in broiler diets.

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Conflict of Interests

There is no conflict of interest.

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