Original Research

Inclusion of Oat Hulls as a Source of Insoluble Fiber in Broiler Diet- An Alternative to AGP

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Abstract

Inclusion of 2.00 % oat hulls (OH) as natural insoluble fiber (IF) source in broiler diet with or without antibiotic growth promoters (AGP) use was studied on broiler performance for six weeks. Day-old chicks (n=315) were assigned to A, B, C, D and E groups containing 63 chicks in each, where A was control with AGP. Groups B, C, D and E were fed with 2.00 % OH with or without AGP, however D and E were low in calorie-protein. Growth performance was comparable between 2.00% OH without AGP groups (C and E) and with AGP groups (B and D). The IF from OH decreased gizzard pH and increased gizzard weight and width. Inclusion of 2.00 % OH in broiler diet showed significant improvement in Ready-to-Cook yield and numerical improvement in carcass eviscerated and giblet yield. The AGP can be replaced with OH as source of natural IF in broiler diet.

Key words: Oat Hulls, Insoluble Fiber, Broiler Chicken

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Introduction

Poultry industry is one of the fastest growing segments in India and it is looking forward to make antibiotic growth promoter (AGP) free poultry diet. Therefore, it is necessary to develop alternatives to antibiotics without affecting physiological functions, productivity and profitability of poultry. The acidifiers, pre and pro-biotic, yeast extracts, herbs and phytogenic compounds etc. have been studied to replace AGP in poultry feed. The strategy of nutritional modification of the poultry diet is also being used by considering the modern capabilities of broiler birds. Moderate amounts of selected fiber sources might benefit the development and function of digestive tract, improve nutrient digestibility (Yokhana *et al.*, 2016) and performance in broilers (Adibmoradia *et al.*, 2016). Dietary fiber is also suggested to have a positive effect on the intestinal microflora, gastrointestinal tract especially on organ pH and rate of feed passage and health status of the birds (Mateos *et al.*, 2012, Gracia *et al.*, 2016). Chemically dietary fiber may divide into soluble and IFs.

Natural insoluble, highly lignified fibers might have different effects on the GIT than soluble, low lignin fibers. Coarse, IF sources, such as OH (OH), sunflower hulls (SFH), and cereal straw increase retention time in the upper part of the GIT and stimulate gizzard development (Rogel *et al*., 1987; Jimenez-Moreno *et al*., 2011, 2013), decreased proventricular and gizzard pH, improves the gut health by killing the bacteria through the acid environment in the intestinal tract (Engberg *et al.*, 2004), improving the digestibility of starch, lipids, and other dietary components (Hetland *et al.*, 2005), extend nutrient retention (Jimenez-Moreno *et al*., 2009), develops intestinal villi of broiler chickens (Sarikhan *et al.,* 2010) leading to a faster growth rate. Few studies have been indicated that the natural IF can well replace the AGP with additional advantages.

Therefore by considering the role of natural IF in the broiler production, an experiment was designed to study the effect of inclusion of 2.00% OH as a source of natural IF in isocaloric-isonitrogenous as well as low calorie-low protein (LCLP) diet with or without use of AGP on the growth performance, carcass parameters and economics of broiler production.

Materials and Methods

Experimental Birds and Design

An experiment was conducted for a period of six weeks on straight run commercial day-old broiler chicks of "Vencobb 430Y" strain (n=315) belonging to single hatch. The chicks were weighed and randomly allotted into five treatment groups viz., A, B, C, D and E with three replicates of 21 chicks in each. The chicks were reared in deep litter open sided broiler house. The group "A" was the control fed with commercial basal diet with AGP. The birds from group B and C were fed with 2.00 % OH with or without AGP (Chlortetracycline(@ 350g/ ton of feed), respectively. The diets for groups A, B and C were isocaloric-isonitrogenous (ICIP). The birds from group D and E were fed with 2.00 % OH with or without AGP (Chlortetracycline(@ 350g/ ton of feed), respectively but these diets were low-calorie low-protein (LCLP: 100 Kcal less ME/Kg) and 2.5% less of total CP and amino acids) than group A, B and C. During the formulation of diets for groups B, C, D and E, 1.00 % soy oil and 1.00% SBM was replaced by 2.00 % OH. The broiler pre-starter, starter and finisher diet I and II were fed *ad libitum* to the birds from 0-10, 11-21, 22-35, 36-42 days of age. The estimated chemical composition of OH is given in table 1. The ingredient composition and chemical composition of broiler pre-starter, starter and finisher I and II diets for different

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groups were depicted in Tables 2, 3, 4 and 5, respectively. All the chicks were provided with uniform floor, feeder and drinker space and were reared under standard management conditions throughout the experimental period of six weeks. The birds were vaccinated against Ranikhet disease at 7th and 28th day of age and against Gumboro disease at 9th and 18th day of age. Following parameters were studied during the experimental period.

Table 1: Proximate composition of OH used in the experiment

Parameter	Percent Level
Moisture	5
Crude Protein	2.5
Crude Fat	0.5
Crude Fiber	35
Total Ash	3
Acid Insoluble Ash	0.5

Table 2: Ingredient composition and chemical composition of Broiler Pre-starter (BPS) diet for different dietary groups

Ingredients (%)	Group A	Group B	Group C	Group D	Group E
Maize	60	56.6	56.6	60	60
Soya DOC 45%	29	30	30	28	28
GNC DOC 43%	3	3	3	3	3
Meat cum bone meal	4	4	4	4	4
Lime stone powder	0.6	0.6	0.6	0.6	0.6
Soya Oil	1	2.4	2.4	-	-
BPS Premix*	2.4	2.4	2.4	2.4	2.4
IF (IF)	-	2	2	2	2
AGP (Chlortetracylcine)	0.0.35	0.035	-	0.035	-
Chemical Composition					
ME (Kcal/Kg)	2958.32	2947.98	2947.98	2850.24	2850.24
Crude Protein %	22.4	22.42	22.42	21.85	21.85
Ether Extract %	3.52	3.36	3.36	3.44	3.44
Crude Fiber %	3.5	4	4	3.5	3.5
Total Ash %	5	5	5	3	3
Total Calcium %	1	1	1	1	1
Available Phophorus%	0.48	0.48	0.48	0.48	0.48
Lysine %	1.32	1.32	1.32	1.24	1.24
Met+Cyst %	0.95	0.94	0.94	0.91	0.91
Threonine %	0.93	0.93	0.93	0.88	0.88
Trptophan %	0.21	0.21	0.21	0.21	0.21
Arginine %	1.35	1.37	1.37	1.32	1.32
Valine %	1.01	1	1	0.98	0.98

**BPS premix (per ton of feed) : 300g vitamin premix, 500g organic trace minerals, 1200g Choline chloride (60%), 500g Hepatocare, 500 g toxin binder,500g coccidiostat , 100g Phytase (5000 IU), 3600g DL-Methionine, 2000g Salt, 3000g Soda bi-carbonate, 2500g L-Threonine, 1500g L-Valine*

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Table 3: Ingredient composition and chemical composition of broiler starter (BS) diet for different dietary groups

Ingredients (%)	**Group A**	**Group B**	**Group C**	**Group D**	**Group E**
Maize	63.6	59.2	59.2	63.5	63.5
Soya DOC 45%	26	27	27	25	25
GNC DOC 43%	3	3	3	3	3
Meat cum bone meal	3.6	3.6	3.6	3.6	3.6
Lime stone powder	0.5	0.5	0.5	0.5	0.5
Soya Oil	1.3	2.7	2.7	0.4	0.4
BS Premix*	2	2	2	2	2
IF (IF)	-	2	2	2	2
AGP (Chlortetracylcine)	0.035	0.035	-	0.035	-
Chemical Composition					
ME (Kcal/Kg)	3012.8	3002.88	3002.88	2913.5	2913.5
Crude Protein %	21.02	20.96	20.96	20.47	20.47
Ether Extract %	3.45	3.72	3.72	3.5	3.5
Crude Fiber %	2	3.5	3.5	2.5	2.5
Total Ash %	5	5	5	4	4
Total Calcium %	0.96	0.96	0.96	0.96	0.96
Available Phophorus%	0.45	0.45	0.45	0.45	0.45
Lysine %	1.19	1.19	1.19	1.17	1.17
Met+Cyst %	0.88	0.88	0.88	0.87	0.87
Threonine %	0.8	0.8	0.8	0.78	0.78
Trptophan %	0.2	0.2	0.2	0.19	0.19
Arginine %	1.26	1.27	1.27	1.23	1.23
Valine %	0.91	0.91	0.91	0.89	0.89

**BS Premix (per ton of feed) : 270g vitamin premix, 450g organic trace minerals, 1000g Choline chloride (60%), 450g Hepatocare,450g toxin binder,500g coccidiostat , 100g Phytase (5000 IU), 3200g DL-Methionine, 2000g Salt, 2500g Soda bi-carbonate, 1600g L-Threonine, 1100g L-Valine .*

Performance Parameters

The body weights (BW) in g of broilers were recorded replicate wise at weekly interval and from these data average cumulative BW and body weight gain (BWG) in g per bird were calculated for various treatment groups for 0-3 and 0-6 week periods. Feed intake (FI) in g was recorded replicate wise at weekly interval and cumulative FI per bird was calculated for various treatment groups for 0-3 and 0-6 week periods. Feed conversion ratio (FCR) was calculated in each replicate based on cumulative body weight and feed intake for 0-3 and 0-6 week periods.

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Table 4: Ingredient composition and chemical composition of broiler finisher (BF) diet I for different dietary groups

Ingredients (%)	Group A	Group B	Group C	Group D	Group E
Maize	67.7	63.5	63.5	67.6	67.6
Soya DOC 45%	23.2	24.1	24.1	22.1	22.1
GNC DOC 43%	2	2	2	2	2
Meat cum bone meal	3.2	3.2	3.2	3.2	3.2
Lime stone powder	0.4	0.4	0.4	0.4	0.4
Soya Oil	1.8	3.1	3.1	1	1
BF Premix*	1.7	1.7	1.7	1.7	1.7
IF	-	2	2	2	2
AGP (Chlortetracycline)	0.0.35	0.035	-	0.035	-
Chemical Composition					
ME (Kcal/Kg)	3082.74	3069.26	3069.26	2989.04	2989.04
Crude Protein %	19.41	19.36	19.36	18.84	18.84
Ether Extract %	3	3.22	3.22	3.5	3.5
Crude Fiber %	2.5	2.5	2.5	2.5	2.5
Total Ash %	4	5	5	5	5
Total Calcium %	0.88	0.88	0.88	0.88	0.88
Available Phophorus%	0.42	0.42	0.42	0.42	0.42
Lysine %	1.08	1.08	1.08	1.05	1.05
Met+Cyst %	0.82	0.82	0.82	0.81	0.81
Threonine %	0.7	0.7	0.7	0.69	0.69
Trptophan %	0.18	0.18	0.18	0.18	0.18
Arginine %	1.13	1.15	1.15	1.1	1.1
Valine %	0.79	0.79	0.79	0.77	0.77

**BF Premix (per ton of feed) : 240g vitamin premix, 400g organic trace minerals, 800g Choline chloride (60%), 400g Hepatocare,400g toxin binder,500g coccidiostat , 100g Phytase (5000 IU), 3000g DL-Methionine, 2000g Salt, 200g Soda bi-carbonate, 1100g L-Threonine,500g L-Valine*

Carcass Traits and Gizzard Width

At the end of 4th and 6th week of age, one broiler from each replicate was fasted for four hours and slaughtered. The percent eviscerated yield, giblet yield and Ready-to-Cook (R-to-C) yield was calculated on the basis of BW of broilers. The percent liver, heart, gizzard weights were also calculated on the basis of BW. The gizzard width (mm) at its two maximum points was recorded with the help of Vernier caliper and average gizzard width was arrived at.

Gizzard pH

Gizzard organs were collected from the slaughtered birds at 4th and 6th week of age for determining the pH. The gizzard contents (5.0 g) were taken and immersed in 50 ml of distilled water. It was then stirred for 15 minutes; thereafter filtered through filter paper. After completion of filtration, the pH in the filtered liquid was measured using a pH meter (Metler toledio, WTW, Germany).

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Table 5: Ingredient composition and chemical composition of broiler finisher (BF) diet II for different dietary groups

Ingredients (%)	Group A	Group B	Group C	Group D	Group E
Maize	68.2	64.3	64.3	68.4	68.4
Soya DOC 45%	19.5	20.1	20.1	18.1	18.1
GNC DOC 43%	2	2	2	2	2
Meat cum bone meal	3.3	3.3	3.3	3.3	3.3
Lime stone powder	3.2	3.2	3.2	3.2	3.2
Soya Oil	0.4	0.4	0.4	0.4	0.4
Maize	1.8	3.1	3.1	1	1
BF Premix*	1.6	1.61	1.61	1.61	1.61
IF (IF)	-	2	2	2	2
AGP (Chlortetracylcine)	0.0.35	0.035	-	0.035	-
Chemical Composition					
ME (Kcal/Kg)	3116.46	3107.12	3107.12	3026.42	3026.42
Crude Protein %	18.01	17.89	17.89	17.36	17.36
Ether Extract %	3.48	4.32	4.32	3.26	3.26
Crude Fiber %	3	3	3	3	3
Total Ash %	4	5	5	5	5
Total Calcium %	0.88	0.88	0.88	0.88	0.88
Available Phophorus%	0.42	0.42	0.42	0.42	0.42
Lysine %	0.99	1	1	0.96	0.96
Met+Cyst %	0.75	0.76	0.76	0.75	0.75
Threonine %	0.64	0.66	0.66	0.64	0.64
Trptophan %	0.16	0.16	0.16	0.16	0.16
Arginine %	1.04	1.05	1.05	1	1
Valine %	0.68	0.68	0.68	0.66	0.66

**BF Premix (per ton of feed) : 240g vitamin premix, 400g organic trace minerals, 800g Choline chloride (60%), 400g Hepatocare,400g toxin binder,500g coccidiostat , 100g Phytase (5000 IU), 3000g DL-Methionine, 2000g Salt, 200g Soda bi-carbonate, 1100g L-Threonine,500g L-Valine.*

Economics

The cost of production (INR) of per kg live broiler bird was calculated for different groups by taking into account live body weight, feeding cost, chick cost and miscellaneous cost. The net profit per kg BW was calculated for different groups.

Statistical Analysis

The data collected on various parameters were subjected to statistical analysis as per the methods suggested by Snedecor and Cochran (1989).

Result and Discussion

Performance Parameters

The BW, BWG, FI and FCR of broiler birds from 0-3 and 0-6 weeks of age of different dietary groups is depicted in Table 6.

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Body Weight

Among ICIP diets, significantly (P<0.01) higher BW in group B than A and comparable BW in group C than A were recorded. This indicated that, inclusion of 2.00 % OH in broiler diet significantly (P<0.01) improved BW. Among LCLP diet, inclusion of OH and AGP in group D recorded significantly (P<0.01) higher BW as compared to inclusion of OH without AGP in group E for 0-3 week period. With respect to the inclusion of OH, final BW of broilers fed LCLP diets were similar to the BW of broilers fed ICIP diets for period of 0-6 week. Moreover, broiler birds from group E have compensated their BW after three weeks of age and attained BW similar to control A as well as group C. The present findings are in agreement with Jimenez-Moreno *et al* (2016). Birds fed a diet diluted with 50% OH showed higher metabolizable energy values than expected (Leeson and Zobair, 1997) and OH dilution could influence general availability of nutrients in the diet (Leeson and Zobair, 1997). The inclusion of 2% OH as source of natural IF without AGP increased the BW of broilers in the present study.

Table 6: Live body weight, body weight gain, feed intake and feed conversion ratio of broiler birds from 0-3 and 0-6 weeks of age of different dietary groups

Groups	Live Body Weight (g)		Body Weight Gain (g)		Feed Intake (g)		Feed Conversion Ratio	
	0-3 Weeks	0-6 Weeks	0-3 Weeks	0-6 Weeks	0-3 Weeks	0-6 Weeks	0-3 Weeks	0-6 Weeks
A	801.213^{b}	2358.9	754.710^{b}	2312.397	1051.060^{a}	3626.063	1.312^{a}	1.539
B	834.763^{a}	2524.017	788.103^{a}	2477.357	1009.687^{a}	3767.997	1.210^{c}	1.493
C	797.460^{b}	2356.443	730.480^{b}	2309.463	1016.437^{b}	3604.853	1.275^{abc}	1.53
D	788.380^{b}	2422.35	741.870^{b}	2375.84	1031.650^{a}	3722.737	1.308^{ab}	1.536
E	749.643^{c}	2361.84	703.740^{c}	2315.937	928.233^{b}	3582.633	1.238^{bc}	1.517
SEM	8.147	25.232	8.074	25.257	12.999	27.052	0.013	0.007
P value	0.002	0.143	0.002	0.146	0.005	0.106	0.038	0.355

Values bearing different superscript within the column differed significantly (P<0.05)

Body Weight Gain

Among ICIP diet, significantly (P<0.01) higher BWG in group B than A and comparable BWG in group C with A which indicated that, inclusion of 2.00 % OH as a source natural IF in broiler diet significantly (P<0.01) gained BW at 3rd week. Among LCLP diet, the inclusion of OH with AGP in broiler diet recorded significantly (P<0.01) higher BWG as compared to inclusion of OH without AGP at 3rd weeks of age. Final BWG at 6th weeks of age was not affected by addition of OH with or without AGP in ICIP as well as in LCLP diets. The results of our study indicated that, inclusion of OH as natural source of IF in broiler diet with LCLP diet attained the BWG similar to the ICIP diet. This is in agreement with Mateos *et al.* (2012) and Jimenez-Moreno *et al.* (2011). Broilers need a minimal dietary fiber (inclusion of 0.75–1.5% rice or barley hulls) in the diet to maximize growth performance (Adibmoradi *et al.*, 2016). ICIP diet with OH and AGP inclusion (Group B) gave numerically highest BWG followed by LCLP diet with OH and AGP inclusion (Group D). All other groups with and without AGP and OH inclusion (group A, C and E) reached

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same BWG. This indicated that, natural IF from OH can be an alternative to replace AGP without affecting BWG.

Feed Intake

Addition of AGP in ICIP as well as LCLP diet caused the higher FI than without addition of AGP for 0-3 week period. Addition of 2.00 % OH in ICIP diets with AGP (group B) and without AGP (group C) did not affect the overall FI of broilers from 0-6 weeks of age. Different authors have demonstrated that, inclusion of moderate amounts of insoluble dietary fibers did not affected voluntary FI in broilers (Gonzalez-Alvarado *et al.,* 2007; Jimenez-Moreno *et al.*, 2009; and Jimenez-Moreno *et al.*, 2011; Sarikhan *et al.,* 2010; Gonzalez-Alverado *et al.,* 2010). Among LCLP diets, broilers fed with 2.00% OH with AGP (group D) or without AGP (Group E) did not affected the cumulative FI for 0-3 week period. Senthilkumar and Balakrishnan (2014) reported that, increasing total NSP insoluble fraction decreased energy level to around 227 Kcal and 450 kcal/kg in the diet resulted in significant ($P<0.05$) increase in FI in birds without altering intestinal viscosity and gut morphology. This indicated that, inclusion of 2.00 % OH as a source of natural IF in broiler diet maintained FI of broilers fed with LCLP as well as ICIP non AGP diet without affecting BWG.

Feed Conversion Ratio

The FCR of broilers from 0-3 weeks of age in group B was found to be significantly ($P<0.01$) improved which was followed by group E, C and D than control A. Overall FCR of broiler birds for 0-6 week period in group B and C did not differed significantly than control A. Similarly, the FCR of broiler birds from group D and E did not differ significantly than control A.

Addition of OH in broiler diet improved the FCR. Moreover, improved FCR in group E without AGP indicated more nutrient availability. Inclusion of OH could influence general availability of nutrients in the diet (Leeson and Zobair, 1997; Jiménez-Moreno *et al.,* 2016) which was in agreement with the present findings. Overall FCR (0-6 weeks) of broilers in the groups added with OH in LCLP diet found to be similar with ICIP diet. Broiler chickens could accustom themselves comfortably to diets diluted with fiber in the course of the finishing period (Picard *et al*., 1999). The fiber diluted feed at the starter period may be beneficial for broiler chickens due to the stimulatory effect of the fiber on digestive tract (Kimiaeitalab *et al.,* 2017; Kheravii *et al.,* 2017; Enting *et al.,* 2007). Improved FCR from 0-6 weeks of age (1.493) was observed in group B. The FCR of all other groups was in the range of 1.517 to 1.539. Beneficial effects of fiber inclusion on the growth performance of broilers were related to improved nutrient digestibility rather than to changes in the metabolic pathways and improvement in the development of the digestive tract (Mateos *et al.*, 2012). Inclusion of 3.00% sun flower hulls reduced the pH of the gizzard and improved the

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AMEn content of the diet, without showing any negative effect on chick performance (Kimiaeitalab *et al.*, 2017).

It was inferred that use of OH as a source of natural IF helps to improve the digestibility and availability of nutrient leading to better FCR even without addition of AGP in feed as well as in LCLP diet.

Gizzard pH, Weight and Width

The statistical analysis of data on gizzard pH, gizzard weight and gizzard width of broiler chicken from different dietary treatments is showed in Table 7.

Table 7: Gizzard pH, gizzard weight and width of broiler chicken from different dietary treatments

Groups	Gizzard pH		% Gizzard Weight		Gizzard Width (mm)	
	4 wk	6 wk	4 wk	6 wk	4 wk	6 wk
A	2.59	2.76	1.58	1.777	48.78	55.117
B	1.89	2.517	1.963	1.927	53.1	57.017
C	2.343	2.5	1.983	2.12	53.547	58.32[a]
D	2.467	2.53	1.78	1.997	50.803	56.06
E	2.213	2.63	1.84	2.003	50.983	55.983
SEM	0.089	0.043	0.055	0.061	0.73	0.412
P value	0.096	0.309	0.109	0.55	0.236	0.109

Means bearing different superscript within the column differ significantly, (P<0.05)

Though there was no significant difference in the gizzard pH , there was numerical decrease in the gizzard pH by on an average 0.34 and 0.24 in all OH supplemented groups (B, C, D and E) both at 4[th] and 6[th] weeks of age respectively than control A. Fiber inclusion via OH elevated the retention time in the upper section of the digestive tract (from crop to gizzard) and stimulated the gizzard function and HCl production in proventriculus (Rogel *et al*., 1987; Mateos *et al.*, 2012). The fibrous ingredients such as OH and soy hull decreased the gizzard pH (Jimenez-Moreno *et al*., 2009; Kimiaeitalab *et al.*, 2017). Oat Hulls prolongs the digesta retention in the gizzard. This leads to reductions in gizzard pH due to increased hydrochloric acid (HCl) secretion. Low pH in the gizzard is associated with increased mineral salts solubility which may ease digestion and absorption of minerals in the upper part of the GIT and promote pepsin activity (Guinotte *et al*., 1995). Decreased pH of gizzard has positive effect on intestinal microflora and also arrested the growth of harmful microbes (Mateos *et al.*, 2012).

Numerical higher gizzard weight by 0.31 at 4[th] week and 0.29 at 6[th] week of age was recorded in groups supplemented with OH (B, C, D and E groups) than control group A. Coarse, IF sources, such as OH, sunflower hulls and cereal straw increase retention time in the upper part of the GIT and stimulate gizzard development (Hetland *et al.*, 2005; Rezaei *et al.*, 2011; Jimenez-Moreno *et al.*, 2013). Broiler chickens are fed diets containing high-energy and low-fiber in mash or pellet form results in undeveloped or atrophic gizzard (Sacranie *et al.*, 2012). Feeding of insoluble granite grit or cassava pulp which is a fibrous feedstuff

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improves the performance of broilers by gizzard development (Guray *et al.*, 2016; Khempaka *et al*., 2009, Rogel *et al*., 1987; De Verdal *et al*., 2010; Rezaei *et al*., 2011). Groups B, C, D and E showed numerically increased the gizzard width than control group A at 4th and 6th weeks of age. This indicated that, the inclusion of OH as natural source of IF in the broiler diet increased the gizzard width. Overall results of the study indicated that the natural IF from OH in the broiler diet helps to decrease the gizzard pH and increased gizzard weight and width. Due to increased gizzard weight and width the feed retained for longer time which perhaps increased digestibility and absorption of all nutrients leading to improved performance.

Dressing Parameters

Statistical analysis of data on percent eviscerated yield, giblet yield, R-to-C yield, Liver weight and Heart weight of broilers from different dietary treatments is given Table 8. The R-to-C yield of broilers recorded at 4th week of age from group B and C was significantly ($P<0.05$) higher than control A while group D and E were comparable with control A. The R-to-C yield of broilers recorded at 6th weeks of age from group D was significantly ($P<0.05$) higher followed by B, C and E. The eviscerated yield and giblet yield of broiler birds from group B, C, D and E did not affected significantly than the control A at 4th and 6th week of age. However, slight numerical improvement in the eviscerated yield and giblet yield of broiler birds in these groups were observed than control A. The liver weight and heart weight of broilers in group B, C, D and E were comparable with the control A at 4th and 6th week of age.

Table 8: Percent eviscerated yield, giblet yield, R-to-C yield, liver weight and heart weight of broiler chicken from different dietary treatments

Groups	Eviscerated Yield (%)		Giblet Yield (%)		R-to-C Yield (%)		Liver weight (%)		Heart weight (%)	
	4th wk	6th wk	4th wk	6th wk	4th wk	6th wk	4th wk	6th wk	4th wk	6th wk
A	62.623	64.67	4.227	4.413	66.850^{b}	69.083^{c}	1.993	2	0.66	0.637
B	62.943	66.983	4.963	4.717	67.910^{ab}	71.700^{ab}	2.42	2.083	0.587	0.71
C	64.983	66.11	4.817	4.847	69.797^{a}	70.960^{abc}	2.123	2.053	0.71	0.673
D	61.667	67.883	4.6	4.73	66.263^{b}	72.617^{a}	2.2	2.063	0.617	0.67
E	62.937	64.87	4.493	4.82	67.427^{b}	69.687^{bc}	2.087	2.13	0.57	0.683
SEM	0.432	0.451	0.108	0.093	0.412	0.449	0.081	0.027	0.022	0.02
P value	0.167	0.086	0.242	0.664	0.036	0.047	0.596	0.743	0.267	0.895

Means bearing different superscript within the column differ significantly, ($P<0.05$)

Inclusion of 2.00 % OH in ICIP broiler diet added with or without AGP significantly improved the R-to-C yield than control at 4th week of age. However, inclusion of 2.00 % OH in LCLP diet with or without AGP found to be comparable with control at 4th week of age. The R-to-C yield of all OH added ICIP as well as LCLP diets with or without AGP found to be significantly higher than control at the end of 6th week of age. There was numerical improvement in eviscerated yield and giblet yield of broilers. The liver weight and heart weight of broilers fed with OH were comparable with control. The slight influence of giblet yield

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might be due to numerical increase in the gizzard weight of broilers in OH added groups. Mourao *et al.* (2008) indicated that broilers fed OH had lower carcass weights and carcass relative live weights. However the present findings are not in agreement with their studies. Tossaporn Incharoen, (2013) reported no considerable differences in heart and liver weight by inclusion of rice hulls meal in broiler diet. Inclusion of OH in broiler diet showed significant ($P<0.05$) improvement in the R-to-C yield and numerical improvement in eviscerated and giblet yield of broilers.

Economics

The economics of broiler production is depicted in Table 9. The ICIP diet with IF (group B and C) incurred highest feed cost per kg of live body weight (INR. 37.02) followed by control group A (INR.36.65) while it was INR. 35.55 in LCLP with IF groups (group D and E). The feed cost per kg of live chicken in group E (INR 35.27) observed lowest among all groups and net saving of INR. 1.38 per kg of live chicken over group A which means INR 3.49 per bird (2.4 Kg average body weight). From the economics of the present study it was concluded that by replacing 1.00 % of soya oil and 1.00 % of soy bean meal with 2.00 % OH in practical rations, it might be possible to achieve the saving of INR. 3.00 per bird on feed cost.

Table 9: Economics of broiler production

Particular	Group A	Group B	Group C	Group D	Group E
Live body weight, Kg	2.358	2.524	2.356	2.422	2.361
Total feed intake, Kg	3.626	3.767	3.604	3.722	3.582
Feed cost. /Kg (INR)	23.84	24.54	24.47	23.32	23.25
Total Feed Cost/kg of live body weight, (INR)	86.44	92.44	88.19	86.79	83.28
Average feed cost /kg of live body weight, (INR)				85.03	
Saving on feed cost /bird over control, (INR)				1.41	

Conclusion

The overall results indicated that, the inclusion of 2.00 % OH as a source of natural IF in ICIP non-AGP diet (group C) as well as LCLP non-AGP diet (group E) did not showed significant difference in the performance (0-6 weeks) of broilers from that of AGP added groups B and D. Moreover, the IF from OH in the broiler diet led to decrease in the gizzard pH and increase in gizzard weight and width. Inclusion of 2.00 % OH in broiler diet showed significant ($P<0.05$) improvement in the R-to-C yield and numerical improvement in eviscerated and giblet yield of broilers. The experiment also suggested that, practically it might be possible to replace 1.00 % of soy oil and 1.00 % of soy bean meal by 2.00 % OH which gave economical benefit of INR. 3.00 per bird without affecting the performance of broilers. It was concluded that, AGP removal from feed can be possible with the help of OH as source of natural IF.

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Conflict of Interest

No potential conflict of interest was reported by the author.

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