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The Effect of Different Sources of Insoluble Fiber on Performance and Carcass Characteristics in Broiler Chicken

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ABSTRACT

This experiment was designed to investigate the effects of using different insoluble fiber sources on broiler chicken's performance and carcass characteristics. Two hundred, (200) day-old commercial male broiler chicks were randomly allotted to 4 dietary treatments with 10 replicates containing 5 birds in each replicate. The treatments consisted of a control diet and three test diets containing 2.5% insoluble fiber sources either rice hulls (RH), soya hulls (SH), or lignocellulose (Arbocel-AC). The dietary addition of lignocellulose and soya hulls significantly ($P<0.01$) improved the body weight gain. Dietary treatments did not influence overall feed consumption. Supplementation of insoluble fiber significantly ($P<0.05$) improved the feed conversion ratio (FCR) when compared to the control. The weight of liver, heart, dressing percentage and abdominal fat percent were not influenced ($P>0.05$) by the dietary treatments except the relative weight of the gizzard which was significantly ($P<0.05$) higher in birds supplemented with rice hulls than other dietary treatment groups. In summary, adding soya hulls and lignocellulose at 2.5% level improved the growth performance of broiler chicken.

KEY WORDS: Broiler, Carcass Characteristics, Growth Performance, Insoluble Fiber, Livability

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INTRODUCTION

The modern-day broiler chicken is more efficient in converting feed into muscle mass. This enhanced efficiency emanates from better nutrition, absorption and metabolism. Therefore, the gut has become a research focus, especially after the ban on antibiotics as growth promoters (AGP) in poultry. In pursuance of better gut health in the post-AGP era, many alternative strategies are being continuously explored. A beneficial shift in the microbial ecosystem of chickens can be promoted by many dietary and non-dietary interventions. Among dietary constituents, the inclusion of low levels of fibers in poultry diets has been shown to promote gut health and microflora (McCleary and Prosky, 2001).

Dietary fiber in commercial poultry feed formulations is usually considered as an anti-nutritional factor that negatively affects feed consumption and nutrient digestibility (Navidshad et al., 2015). However, recent reports emphasize the positive effects of incorporating of moderate dosage of insoluble fibre in the diet. An adequate type and amount of fiber improves the adaptation of the GIT of poultry to present productive systems and reduces digestive disturbances without supplementing feed antibiotics (Montagne et al., 2003). The inclusion of various insoluble fiber sources as feed additives in the diets of broiler and layer birds has been shown to induce positive changes in digestive physiology (Hetland et al., 2005) and increase the retention time of ingested food in the upper part of the gastrointestinal tract, stimulate gizzard development (Jimenez-Moreno et al., 2013) decrease proventricular and gizzard pH and improve the gut health by killing the bacteria through the acid environment in the intestinal tract (Engberg et al., 2004), improves starch, lipid and other dietary components digestibility (Hetland et al., 2005), nutrient retention (Jimenez-Moreno et al., 2009). All these factors together, can promote nutrient digestibility and growth performance of birds (Jha and Berrocoso, 2016). Rice hulls, sunflower hulls, oat hulls and soy hulls are some of the insoluble fiber sources that have been reported to affect nutrient utilization and growth performance positively in broilers (Gonzalez-Alvarado et al., 2007). Among the insoluble hulls, rice hulls and soya hulls are commonly available and comparatively cheap compared to other hulls.

Rice hulls are a by-product produced during the milling of rice (*Oryza sativa*) and they account for 20% of the total rice production (Feng et al., 2004). Rice hulls contain about 87.3% of insoluble fiber and 2.7% of soluble fiber (Podolske, 2013). Major NSPs present in rice hulls are cellulose and lignin. Soybean hulls are the outer coating of each soybean seed. The hulls are a byproduct of standard soybean processing. Soya hulls contain about 49.3% of insoluble fibers and 13.3% of soluble fiber. Purified lignocellulose (Arbocel) is the special dietary insoluble fiber product used in poultry nutrition due to its positive effect on the digestive process and gut health, these insoluble fibers are said to help birds digest nutrients more efficiently (Hetland et al., 2005). So the present study is conducted to assess the effect of adding different insoluble fiber sources to the broiler diet on the performance and carcass characteristics of broiler chickens from 0–42 days of age.

MATERIALS AND METHODS

The present research trial was approved by the Institutional Animal Ethics Committee of the College of Veterinary Science, P.V. Narsimha Rao Telangana Veterinary University, Telangana, India vide 19/24/ C.V.Sc, Hyd. IAEC-poultry/12.06.2021.

To conduct the proposed study, Two hundred, (200) day-old commercial male broiler chicks were randomly allotted to 4 dietary treatments with 10 replicates containing 5 birds in each replicate. The treatments consisted of a corn-soybean meal based control diet and three test diets containing 2.5% insoluble fiber sources either rice hulls (RH), soya hulls (SH) or lignocellulose (Arbocel-AC). Broiler pre-starter (1-14 days), starter (15-28 days) and finisher (29-42 days) diets were formulated to contain 22.5%, 21.0% and 19.5% crude protein and metabolizable energy was 3000, 3125 and 3250 kcal/ kg respectively as per Vencobb recommendations (Table 2). For the duration of the experiment, water and feed were given on an *ad-lib* basis.

Birds were immunized against New Castle disease (ND) with the Lasota vaccine on the 7th (primary) and 28th (booster) days of age and the Infectious bursal disease (intermediate – Georgia strain) vaccine on the 14th (primary) and 21st (booster) days of age.

The source of fiber used in this experiment is Arbocell (JRS Pharma, Germany) as commercial fiber, it is 100% composed of insoluble fibers derived from heartwood. Soya hull and rice hull (RH) as traditional fibers. The chemical composition of fiber sources can be found in Table 1.

Body weight was recorded for individual birds on a weekly basis, while the cumulative feed consumption of each replicate was recorded at weekly intervals, up to 42 days of age. The feed conversion ratio (FCR) was calculated as (feed intake/body weight gain).

At the end of the trial (42d of age), 6 birds per treatment were slaughtered to study the carcass parameters. The bird weighing to the mean body weight of the respective treatment was selected, fasted overnight and slaughtered by cervical dislocation to study the relative weights of organs like liver, heart, gizzard and percentage of dressing yield and abdominal fat.

Table 1. Chemical analysis (%) of fiber source

	Rice hulls	Soya hulls	Lignocellulose (Arbocel)
Crude fiber %	46.3	8.69	59.1
Neutral detergent fiber %	89.0	39.4	87.0
Acid detergent fiber%	73.1	13.2	72.9
Acid detergent lignin%	18.4	2.83	27.8
Cellulose%	38.5	9.56	44.7
Hemicellulose %	15.8	26.2	14.1
Silica%	18.0	1.56	1.59

Table 2. Ingredient composition of fiber diet (in kgs) fed to the commercial broilers from 0-42 days.

Ingredient	Pre-starter (0-14d)	Starter (15-28d)	Finisher (29-42d)
Maize	53.3	55.2	57.4
Oil	3.54	5.22	6.81
Soybean meal	32	28.6	24.9
MBM 45%	6	6	6
Salt	0.31	0.31	0.32
Dicalcium phosphate	0.47	0.47	0.4
Shell grit	0.82	0.82	0.77
DL-Methionine	0.3	0.24	0.22
L-Lysine HCL	0.24	0.16	0.12
L-Threonine	0.01	0.001	0.002
L-Arginine	0.082	0	0
Choline chloride 75%	0.1	0.1	0.1
Toxin binder	0.1	0.1	0.1
Trace mineral mixture	0.1	0.1	0.1
Coccidiostat	0.05	0.05	0.05
Vitamin premix	0.05	0.05	0.05
RH/SH/Arbocel	2.5	2.5	2.5
Total	100	100	100
Nutrient composition (calculated values)			
ME (kcal/kg)	3000	3125	3250
Crude protein (%)	22.5	21.0	19.5
Crude fiber (%)	6.74	6.58	6.41
Lysine (%)	1.25	1.10	1
Methionine (%)	0.61	0.54	0.50
Calcium (%)	0.94	0.92	0.88
Available phosphorus (%)	0.45	0.42	0.40

*Vitamin premix provided per kg diet: Vitamin A 200000IU, Vitamin D3 3000IU, Vitamin E 10mg, Vitamin K 2mg, Riboflavin 25mg, Vitamin B1 1mg, Vitamin B6 2mg, Vitamin B12 40mg, and Niacin 15mg.
*Trace mineral provided per kg diet: Manganese 120mg, Zinc 80mg, Iron 25mg, Copper 10mg, Iodine 1mg and Selenium 0.1mg.

The data was analyzed using the General Linear Model procedure of Statistical Package for Social Sciences (SPSS) 20th version and comparison of means was done using Duncan's multiple range test (Duncan, 1955) and significance was considered at P<0.05. Data were subjected to statistical analysis under a completely randomized design employing one-way analysis of variance (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Body weight gain

The results showed that during pre-starter phase, broilers fed with lignocellulose (AC) had significantly (P<0.01) higher body weight gain (BWG) than other treatments. During the starter phase, soya hulls fed birds had higher BWG than the rest of the treatments. In the finisher phase, no significant difference was observed among dietary treatments. In overall period BWG was significantly (P<0.05) increased in birds supplemented with 2.5 % lignocellulose than birds fed on rice hulls and control group and was comparable to birds fed with soya hulls (Table 3).

These findings are consistent with data reported by Gonzalez-Alvardo et al. (2007) and Scapini et al. (2018) who observed an improved body weight gain by supplementation of 3% of oat hulls and 5% of soya hulls respectively in the broiler's diet. Also, Sozcu and Ipek (2020) showed significantly increased body weight gain with the inclusion of lignocellulose in the diet of broilers.

Table 3. Effect of different sources of insoluble fiber on phase wise bodyweight gain (g)

Treatments	Pre starter phase (1-14d)	Starter phase (15-28d)	Finisher phase (29-42d)	Overall BWG (1-42d)
Control	301^{b}	7625^{b}	901.89	1965^{c}
RH	312^{b}	770^{b}	931	2014^{bc}
SH	306^{b}	822^{a}	949	2033^{ab}
AC	341^{a}	774^{b}	917	2076^{a}
SEM	3.75	5.23	7.96	9.72
N	8	8	8	8
P value	0.002	0.006	0.429	0.001

Values bearing different superscripts within a column are significantly (P<0.05) different.
P value =probability value; N = number of replicates (5 birds in each replicate); SEM = Standard Error Mean; NC =Negative control; PC = Positive control; RH = Rice hulls; SH = Soy hulls; AC = Arbocel

The above findings indicate that broilers need a moderate amount of fiber to improve growth performance. This positive effect on body weight gain may be attributed to the stimulating effect of fiber on gizzard development (Hetland and Svihus, 2001), thereby reducing the gastric pH and creating a better environment for pepsin action, increasing the gastric proteolytic activity of digestive enzymes (Yokhana et al., 2016), improving the digestibility of starch, lipids and amino acids by killing the bacteria through the acid environment (Engberg et al., 2004; Farran et al., 2017), improved digestion and assimilation of nutrients (Boguslawska, 2015) and increased nutrient digestibility can lead to higher body weight gain (Yokhana et al., 2016) in broiler chicken

Feed intake

The results revealed that feed consumption of birds was not significantly influenced by the dietary treatments (Table 4). These results are in accordance with the findings of Santos et al. (2019) who reported feed consumption was not affected by the supplementation of rice hulls (2.5% and 5%) and soy hulls (2.5% and 5%) in broilers. Similarly, Hetland et al. (2003), Cao et al. (2003) and Sarikhan et al. (2010) also observed no significant difference in feed consumption with the supplementation of 3% oat hulls, 7.5% and 10% of lignocellulose, respectively in broiler diet. This might be due to the concentration of insoluble fiber in the diets having little impact on dietary energy availability. The results were in agreement with the findings of Basak et al. (2002) and Olugbemi et al. (2010) who found that fiber feedstuff can be incorporated safely into broiler diets up to 5%.

Table 4. Effect of different sources of insoluble fiber on phase wise feed intake (g) in broiler chicken

Treatments	Pre starter phase (1-14d)	Starter phase (15-28d)	Finisher phase (29-42d)	Overall feed consumption (1-42d)
Control	413	1214	1742	3369
RH	402	1205	1764	3371
SH	382	1269	1716	3327
AC	413	1224	1689	3367
SEM	4.39	7.6	11.5	14.1
N	8	8	8	8
P value	0.152	0.07	0.508	0.513

Feed conversion ratio (FCR)

During the pre-starter phase, FCR was significantly (P<0.05) better in AC (lignocellulose) than birds fed on rice hulls and the control group and was comparable to birds fed with soya hulls (Table 5). In the starter and finisher phases, no significant difference was observed among dietary treatments. Overall FCR was significantly (P<0.04) improved in all the fiber supplemented groups when compared to the control.

The improved feed conversion ratio with the supplementation of insoluble fiber as observed in this study was in agreement with the results of Khazari et al. (2019) who reported that supplementation of rice hulls, soya hulls (30g/kg) and arbocel (18g/kg) in the broiler diet improved FCR. The results of the present study are also in concurrence with the findings of Adibmoradi et al. (2016) and Bojarpou (2020) who reported the dietary inclusion of rice hulls (0.75%) and soya hulls (2.5%, 5% and 7.5%) respectively in the broiler diet had a significant effect on FCR. The fiber, improved nutrient digestibility and availability of nutrients (Hetland and Svihus, 2001) rather than changes in metabolic pathways leading to better feed efficiency.

Table 5. Effect of different sources of insoluble fiber on cumulative FCR of broilers

Treatments	Prestarter phase (1-14d)	Starter phase (15-28d)	Finisher Phase (29-42d)	Overall FCR (1-42d)
Control	1.38^{c}	1.59	1.93	1.72^{c}
RH	1.29^{b}	1.57	1.90	1.67^{b}
SH	1.25^{ab}	1.54	1.82	1.64^{a}
AC	1.21^{a}	1.58	1.84	1.62^{a}
SEM	0.13	0.01	0.02	0.01
N	8	8	8	8
P-value	0.001	0.25	0.60	0.04

Values bearing different superscripts within a column are significantly (P<0.05) different.

Carcass characteristics

The weight of the liver, heart, abdominal fat and dressing percentage on live weight were not significantly influenced (P>0.05) by the dietary treatments (Table 6). The relative weight of the gizzard was significantly (P<0.05) higher in birds supplemented with rice hulls compared to the other dietary treatment groups.

The above results were in agreement with Incharoen (2013) and Adibmoradi et al. (2016) who observed no significant difference in abdominal fat weights with supplementation of 100g/kg and 0.75% of rice hulls, respectively. Mourao et al. (2008) indicated that broilers fed 10% of oat hulls had no significant difference in carcass relative live weights. Jimenez-Moreno et al. (2011) and Gonzalez-Alvadaro et al. (2007) observed higher relative gizzard weight with supplementation of 2.5% of pea hulls and 3% of soya hulls respectively in the broiler's diet.

The increased gizzard weight might be due to the high fiber content in which RH is difficult to grind, therefore considerable amounts of hulls remain in the gizzard for longer periods than do regular particles (Hetland et al., 2005). In the present study, the gizzard weight was higher in birds fed RH than in the control group, indicating that fiber was retained longer in the gizzard. However, increased body weight gain in birds given the RH indicated that the presence of insoluble fiber is important to enhance gizzard activity in improving nutrient utilization (Hetland and Svihus, 2001).

Table 6. Effect of different sources of insoluble fiber on carcass characteristics of broiler chicken (% of live weight) at 6th week of age.

Treatments	Dressing percentage	Liver	Heart	Gizzard	Abdominal fat
Control	63.6	1.74	0.55	1.80^{b}	1.33
RH	63.4	1.78	0.59	2.19^{a}	1.25
SH	64.8	1.71	0.51	1.73^{b}	1.23
AC	64.7	1.71	0.50	1.88^{b}	1.23
SEM	0.29	0.03	0.01	0.04	0.06
P	0.15	0.87	0.37	0.007	0.98

Values bearing different superscripts within a column are significantly (P<0.05) different.

Mortality and livability

The mortality and livability of broilers supplemented with different dietary treatments are presented in Table 7. It was observed that mortality and livability was not influenced by the supplementation of different dietary treatments. Mortality was observed in all the treatment groups except the diet supplemented with SH. However, the mortality rate was within acceptable range and no specific disease outbreak was recorded. Similar results were reported by Kheravii et al. (2018) with the supplementation of 0.2% lignocellulose had no effect on the livability of broilers.

Table 7. Effect of different sources of insoluble fiber on mortality and livability of broiler chicken.

Treatment	No. of birds housed	No. of birds died	Mortality %				Livability %
			1-14d	15-28d	29-42d	Cause of death	
Control	50	1	2	-	-	Unabsorbed yolk condition	98.0
RH	50	1	2		-	Unabsorbed yolk condition	98.0
SH	50	-	-	-	-	-	100
AC	50	1	-	2	-	Unabsorbed yolk condition	98.0

CONCLUSION

Based on the overall results, it is concluded that supplementation of soy hulls and lignocellulose at 2.5% may be supplemented to broilers for improved growth performance.

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