Effect of fiber source on growth performance and gastrointestinal tract in broiler chickens

I Nursiam¹, M Ridla², W Hermana² and Nahrowi²

¹Graduate School of Nutrition and Feed Science, IPB University, Jalan Raya Dramaga, Bogor 16680, Indonesia
²Departments of Nutrition and Feed Technology, IPB University, Jalan Raya Dramaga, Bogor 16680, Indonesia

Email: intan_nur2703@apps.ipb.ac.id

Abstract. This experiment was conducted to assess the effect of the addition of a fiber source on growth performance and gastrointestinal tract in 7–28 day broiler chicken. In total, of 1600 mixed-sex Cobb 500 chicks aged 7 days were assigned to 4 treatments composed of 4 replicates with 100 birds per replicate. The 4 treatments were: control diet (T1), control diet + 0.6% commercial fiber source 1 (T2), control diet + 1% commercial fiber source 2 (T3), control diet + 2% rice hulls (T4). The addition of fiber did not affect on growth performance, relative weight, and digestive length of broiler chickens aged 7 to 28 days. In summary, adding some fiber at a moderate level as insoluble fiber not any negative impact on growth performance and gastrointestinal development, and can be a strategy to reduce feed cost in broiler farming.

1. Introduction

Feed costs are the most expensive component of broiler production, representing more than 70% of the total cost of production. The requirement to reduce feed cost, increase feed efficiency and reduce the use of antibiotic growth promoters (AGP) in feeds has encouraged nutritionists to explore other strategies to address this issue. The function of the different segments of the digestive tract can be affected by the diet and feeding system [1]. Recent studies have highlighted the potential benefit of using a structural component such as manipulating particle size, adding whole grain and insoluble fiber to improve the gastrointestinal tract (GIT) development of broiler chicken.

Fibers are the majority part of all plant feedstuffs with a large amount and the chemical structure depends on species, plants and maturity stage. Fiber is one of the most important nutrients in poultry. On the other hand, dietary fiber was considered as a diluent or as an anti-nutritional factor in poultry feed [2], with negative effects on voluntary energy consumption and nutrient digestibility [3]. Dietary fibers are divided into two categories: water-soluble and insoluble dietary fiber [4]. The type of fiber affects the yield and digestive traits of broiler chickens with effects varying depending on the age of the birds. Insoluble fibers, such as cellulose, non-starch polysaccharides (NSP) and lignin can affect intestinal functions, modulates nutrient digestion and passage rate when a moderate level in the diet [5].

Applying rich source of insoluble fiber in the diet could boost the development of the gastrointestinal tract (GIT), particularly the front intestine (proventriculus and gizzard) [6–12]. Adding 3% coarse fiber, such as oat hulls, to diets can boost gizzard development [13]. The minimum level of total dietary fiber
in young broiler 81.2–93.2 g/kg diet (25.6–35.0 g crude fiber/kg diet), an excess of total dietary fiber (above 93.2 g/kg diet) might reduce nutrient digestibility and growth performance [14].

The objectives of this study were to assess the effects of adding fiber source to broiler diet with on the performance and gastrointestinal of broiler chickens during growing period (7–28 days).

2. Research method

2.1. Source of fiber, diet, and birds

The source of fiber used in this experiment is Arbocell (JRS Pharma, Germany) as commercial fiber 1 (CF1), Opticell (Agromed, Austria) as commercial fiber 2 (CF2) and rice hull (RH) as traditional fiber. CF1 is 100% composed of insoluble fibers derived from heartwood and CF2 contains insoluble fibers and soluble fiber derived from a mixture of heartwood and bark. The chemical composition of fiber sources can be found in table 1.

Corn, wheat, and soybean diets have been formulated to meet the nutrient requirements of broiler chickens during growth, in accordance with the Cobb Nutrient Requirement Guideline (table 2). All experimental diets supplied as crumble and fed from 7 to 28 days. The experimental treatments were as follows: T1, control diets; T2, control diets + 0.6% CF1; T3, control diets + 1% CF2; and T4, control diets + 2% RH. A total of 1600 unsexed broiler (Cobb 500) at seven days old, with an initial weight of 198.0 ± 6.4 g, were randomly placed into 16 cages containing 100 birds per cage. Feed and water provided ad libitum.

| Item                        | CF1    | CF2    | RH    |
|-----------------------------|--------|--------|-------|
| Moisture                    | 8.80   | 10.10  | 9.00  |
| Crude protein               | 0.63   | 1.58   | 3.50  |
| Ether extract               | 0.38   | 0.55   | 0.32  |
| Ash                         | 0.31   | 1.03   | 19.58 |
| Neutral detergent fiber     | 89.08  | 88.00  | 88.00 |
| Acid detergent fiber        | 75.79  | 71.34  | 70.24 |
| Gross energy (kcal/kg)      | 4,148  | 4,150  | 3,062 |

2.2. Growth performance and GIT evaluation

The body weight of the chicks and feed consumption were determined by cage at the beginning of the trial (7 days of age) and the end of the trial period (28 days of age). Using the data obtained, the daily body weight gains (BWG), average daily feed intake (ADFI) and feed-gain ratio were determined. At age 21 days, a chick per cage was randomly selected, weighed and dissected into the jugular vein. The GIT without digestive content and liver were removed and weighed separately. Empty GIT and liver weights were expressed relative to kg live BW (g/kg BW).

2.3. Statistical analysis

For the growth performance parameter, the cage means used as the experimental unit for statistical analysis and for organ weight measurements, the individual birds were considered to be the experimental unit. Growth performance and GIT weight data were assessed using the GLM procedure on SPSS statistical software. Significant differences in treatment means were compared using the Duncan test and the differences were accounted for at the statistical level of P<0.05.
Table 2. Ingredient composition and chemical analysis (% as feed basis) of experiment diets.

| Raw material, g/kg | T1   | T2   | T3   | T4   |
|-------------------|------|------|------|------|
| Corn              | 340.43 | 338.39 | 337.03 | 333.62 |
| Wheat             | 234   | 232.6 | 231.66 | 229.32 |
| Rice bran         | 24    | 23.86 | 23.76  | 23.52  |
| Soy bean meal     | 266   | 264.4 | 263.34 | 260.68 |
| DDGS              | 10    | 9.94  | 9.9    | 9.8    |
| Corn gluten meal  | 15    | 14.91 | 14.85  | 14.7   |
| Crude palm oil    | 40    | 39.76 | 39.6   | 39.2   |
| Full fat soya     | 37.1  | 36.88 | 36.73  | 36.36  |
| Lime stone        | 10.24 | 10.18 | 10.14  | 10.04  |
| MDCP              | 3.6   | 3.58  | 3.56   | 3.53   |
| Salt              | 2.05  | 2.04  | 2.03   | 2.01   |
| Sodium bicarbonate| 1    | 1     | 1      | 1      |
| L-lysine HCl      | 2.89  | 2.87  | 2.86   | 2.83   |
| DL-methionine     | 2.26  | 2.25  | 2.24   | 2.21   |
| L-threonine       | 0.79  | 0.79  | 0.78   | 0.77   |
| Choline Cl        | 0.64  | 0.64  | 0.63   | 0.63   |
| Premix            | 10    | 10    | 10     | 10     |
| CF 1              | -     | 6     | -      | -      |
| CF 2              | -     | -     | 10     | -      |
| RH                | -     | -     | -      | 20     |
| Determined analysis, % |      |      |       |       |
| Moisture          | 12.34 | 12.32 | 12.32 | 12.27 |
| Crude protein     | 21.57 | 21.44 | 21.37 | 21.21 |
| Ether extract     | 6.98  | 6.94  | 6.92   | 6.85   |
| Ash               | 4.63  | 4.6   | 4.59   | 4.93   |
| Neutral detergent fiber | 24.59 | 24.98 | 25.22 | 25.86 |
| Acid detergent fiber | 8.97  | 9.37  | 9.59   | 10.2   |
| ME, kcal/kg       | 3100  | 3081  | 3069   | 3038   |

3. Results and discussion

CF1, CF2 and RH contained in analysis 89.08, 88, and 88% NDF, and 75.79, 71.34 and 70.24% ADF, respectively (table 1). The addition of certain fiber sources increased NDF and ADF and reduced CP and energy content (table 2). The ADF and NDF ratio in this experiment diets 36.48, 37.52, 38.03 and 39.43% for T1, T2, T3 and T4. The result of this experiment is summarized in table 3. The BWG, ADFI and FG of birds from 7 to 28 days were not influenced by addition of a fiber source (P>0.05). In this trial, increasing ADF/NDF ratio by adding a moderate level of fiber source in growing phase of broiler showed can promote higher body weight gain and daily feed intake. Higher feed intake can be influenced by reducing ME in feed by adding some fiber source, but birds have a natural mechanism to maintaining their energy requirements with increasing energy intake. Adding some fiber in broiler diets increased the digestibility of starch, protein, and fat [15]. Increasing nutrient digestibility can be lead to higher body weight gain because birds more efficient using nutrient in their body. The increasing dietary fiber affected broiler performance, but the effects were dependent on the fiber source and the period considered [10].

At 21 days of age, the relative weight of proventriculus, gizzard, liver, small intestine and caecum was not affected by addition of fiber to the feed (P>0.05). Insoluble fibers affect in different ways the
anatomy, physiology, and transit time of the digestion through the GIT in various ways such as particle size, water holding capacity, swelling water capacity and resistance to ground [16, 15]. In this study, the addition of fiber did not increase the proventriculus capacity as a temporary storage organ during the digestion process. However, adding fiber source in broiler feed increased relative weight of the gizzard. The gizzard has a number of important functions, such as helping digestion by reducing particle size, chemical degradation of nutrients, and regulating feed flow [1]. The relative weight of the liver was not affected by the addition of fiber in the feed; this indicated that the addition of fiber did not affect the metabolic processes in the body.

Table 3. Influence of inclusion some fiber source on growth performance, energy intake (EI), energy conversion ratio (ECR), and relative weight of GIT.

| Parameters                               | T1   | T2   | T3   | T4   | SEM  | P-Value |
|------------------------------------------|------|------|------|------|------|---------|
| BWG, g/b/d                               | 49.55| 49.97| 51.03| 51.12| 0.47 | 0.50    |
| ADFI, g/b/d                              | 93.89| 98.90| 101.02| 99.81| 1.69 | 0.61    |
| FG, g/g                                  | 1.89 | 1.98 | 1.98 | 1.95 | 0.03 | 0.66    |
| Energy Intake, kcal/g                    | 291.05| 304.76| 310.04| 303.21| 5.02 | 0.64    |
| ECR, kcal/g BWG                          | 5.87 | 6.10 | 6.08 | 5.93 | 0.08 | 0.73    |
| Relative GIT weight at 21 days of ages   |      |      |      |      |      |         |
| Proventiculus, g/kg BW                   | 6.91 | 7.14 | 7.47 | 6.25 | 0.27 | 0.48    |
| gizzard, g/kg Bw                         | 22.90| 23.91| 24.89| 23.42| 0.49 | 0.57    |
| liver, g/kg BW                           | 29.52| 29.87| 25.74| 26.88| 4.36 | 0.51    |
| Small intestine, g/kg BW                 | 51.95| 50.29| 48.64| 47.03| 2.32 | 0.91    |
| Caecum, g/kg BW                          | 4.98 | 4.75 | 6.14 | 3.69 | 0.35 | 0.08    |
| Small intestine length, cm               | 167.73| 180.56| 179.45| 161.60| 6.29 | 0.70    |
| Caecum length, cm                        | 13.81| 15.38| 15.56| 12.76| 0.56 | 0.24    |

aEnergy Intake : ADFI × ME Feed.

bEnergy Conversion Ratio : Energy intake ÷ BWG.

Relative weight of small intestine in the treatment given additional fiber showed a decreasing trend. This results in line with the report of [9] that the addition of cellulose and wood shavings decreased the relative weight of the small intestine of broiler. Caecum in T3 has the highest weight relative to all treatments; this may be because of the soluble fiber content in CF2. Adding soluble fiber like sugar beet pulp in broiler feed increase caeca weight [6, 7, 17, 18]. The soluble fiber can be fermented in the caecum into short-chain fatty acid like butyric acid which can act as an antibacterial. The length of the small intestine and caecum was inconsistent with the addition of fiber to the feed. The use of CF1 and CF2 where high lignin content affected the length of the small intestine and caecum, the silica content in RH may affect the length of the small intestine and caecum.

4. Conclusion

The addition of any fiber source in broiler diets has a positive impact on the increase in BWG, ADFI, EI and ECR without any negative impact on the GIT function. The ADF/NDF ratio can be adjusted to take advantage of the addition of a fiber source to broiler feed. The addition of fiber source can be an alternative solution to reduce the production costs in broiler farming without negatively impact on production performance.

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