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The effect of peanut pod on performance, small intestine pH and ileum bacteria population in broiler chickens

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Abstract

This experiment was designed to assess the hypothesis that feeding broilers with peanut pod as an insoluble fibre source will result in improved gut digestive capacity growth performance. The experimental diets consisted of a control diet and three diets containing 25, 50, or 75 g peanut pod /kg. The dietary peanut pod, especially at the 50 g/kg level decreased feed intake of the experimental groups. In grower phase, the best weight gain was recorded in the broiler chickens fed the diet containing 75 g peanut pod /kg. All the peanut pod containing diets decreased grower phase feed conversion ratio compared to the control group. In the finisher phase, the growth rate and feed conversion ratio were not affected by the experimental diets. The gizzard weight and gastrointestinal length was increased in the chickens fed 75 g peanut pod /kg, and these groups showed the lowest pH for gizzard content. In the ileum, the birds fed 25 g peanut pod /kg had a higher *Lactobacillus* population than the 75 g peanut pod /kg group; and the birds fed 25 g peanut pod had lower *Escherichia coli* (*E. coli*) population, compared to the control group. The positive effects of dietary insoluble fibre on the growth performance of broilers in this study were probably a result of favourable changes in the bacteria populations and also an increase in digestive capacity of gastrointestinal.

Keywords: Broilers, gut pH, ileum bacteria, peanut pod

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Introduction

Traditionally, in most studies on poultry, dietary fibre has been considered as a diluents factor with a negative impact on voluntary feed intake and digestibility of nutrients (Rougiere *et al.*, 2010; Navidshad *et al.*, 2015). As a result, commercial diets, especially for young chicks, are commonly formulated to contain less than 3% crude fibre (Mateos *et al.*, 2002). Dietary fibre is divided into soluble (viscous and fermentable) and insoluble (non-sticky and non-fermented) types. Soluble fibres, including arabinose, inulin, pectin, gum, beta-glucans and some hemicelluloses, increase the viscosity of intestinal digesta, and also increase the solubility and water holding capacity of diet, which will physically limit the gizzard capacity and increase the retention time of feed in this organ, hence feed intake and growth performance (Jimenez-Moreno *et al.*, 2010; Mateos *et al.*, 2013). Insoluble fibre consists of lignin, cellulose, and some hemi-celluloses which are found in plant cell wall (Bach Knudsen, 2001).

Based on studies in recent years, it has been proven that the use of moderate amounts of dietary insoluble fibre from different sources improves the development of the digestive organs, and increases the secretion of hydrochloric acid, bile acids and digestive enzymes (Gonzalez-Alvarado *et al.*, 2007; Hetland and Svihus, 2007). These changes may improve the digestibility of nutrients (Amerah *et al.*, 2009), growth performance (Gonzalez Alvarado *et al.*, 2010) and the health of the digestive tract (Perez *et al.*, 2011), as well as animal welfare (Van Krimpen *et al.*, 2009). In addition, depending on the amount and type of fibre and the composition of the basal diet, the microbial population in the distal part of the gastrointestinal tract may change. Peanut (*Arachis hypogaea*) is an annual plant of the leguminous family from tropical and subtropical areas. Peanut is considered one of the important oil seeds and peanut meal is used as a protein

source in animal feeding. The locally produced peanut pod in Iran is usually freely presented if someone accepts the transporting costs; however, its availability is seasonal. The outer husk, or pod, is rich in lignocellulosic compounds and is sometimes used as bedding for animals (Lien *et al.*, 1998). As a by-product, large quantities of the peanut pod are produced every year, which could be an ideal and inexpensive lignocellulosic material. This study was designed to evaluate the possibility of using moderate levels of peanut pod in the diet of broilers and its effect on production traits, pH, and the population of lactobacillus and *E.coli* bacteria of the gastrointestinal tract.

Materials and Methods

A batch of the peanut pod was obtained from Astaneh Ashrafieh (Guilan, Iran, 37° 15' 54" N, 49° 56' 40" E) and ground with a hammer mill (Kavian Jam, Co, Iran) to pass through a 2-mm screen. The metabolizable energy of pod samples was determined by the Sibbald procedure (Sibbald, 1976a; Sibbald, 1976b). Briefly, twenty gram samples of peanut pods were fed to each of 10 cockerels, followed by a 48 hour excreta collection period. The nitrogen-corrected true metabolisable energy of the peanut pod sample was determined and all values were corrected to nitrogen balance. The ME was calculated as follows:

$$ME = GE - EE - (8.22 * N)$$

where: ME = metabolisable energy per gram of dry peanut pod,
 GE = gross energy per gram of the peanut pod,
 EE = excreta energy per gram peanut pod consumed, and
 N = grams nitrogen retained.

Dry matter (DM), crude protein (CP), ether extracts (EE), and ash content of the pod and the diets were assayed according to AOAC (2000). Through the Weende method, crude fibre was measured (Henneberg and Stohmann, 1859). The automatic fibre analyzer (Fibretec System M, Tecator) based on the method of Van Soest *et al.* (1991) was used to determine the neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of samples. All chemical analyses were carried out in triplicate and the averaged value was considered for statistical analysis. Table 1 shows the chemical composition of the peanut pod sample used in the experiment.

Table 1 Chemical composition of peanut pod

| Parameter | Quantity |
|----------------------------------|----------|
| Dry matter (g/kg) | 937.8 |
| Metabolisable energy (Kcal/kg) | 1180 |
| Ash (g/kg) | 99.3 |
| Ether extract (g/kg) | 57.9 |
| Crude protein (g/kg) | 122.6 |
| Crude fibre (g/kg) | 312.0 |
| Neutral detergent fibre (g/kg) | 802.8 |
| Acid detergent fibre (g/kg) | 713.6 |
| Water holding capacity (g/g) | 3.4 |
| Bulk density (mL/g) | 0.45 |
| Increased volume (mL/g) | 2.24 |

The physical properties of the peanut pod were measured. A 2.5 g sample of the peanut pod was left to soak for 24 h in 250 mL of distilled water; the sample was then filtered on a fritted glass crucible. The weight of the wet sample was recorded after letting water decant for 10 min. Water holding capacity was the quantity of water retained by the sample and expressed as g per g of sample dry matter (Giger-Reverdin, 2000). Bulk density was measured according to the method of Wang and Kinsella (1976). A 100 mL graduated cylinder was filled to 100 mL with the peanut pod. The sample was packed by softly tapping the cylinder on the bench top 10 times from a height of 5 cm. The volume and weight were recorded and the bulk density was expressed as a ratio of weight (g) of the sample to volume (mL). To measure the increased volume by the method of Gomez-Ordóñez *et al.* (2010), a 500 mg powdered peanut pod was transferred into a 10 mL graduated cylinder and 10 mL distilled water, containing 0.02% sodium azide as bacteriostatic was added. Then, it was stirred quietly to remove trapped air bubbles and left on a level surface at room temperature overnight (18 h) to allow the sample to settle. The volume (mL) taken from the sample was recorded and increased volume was expressed as mL/g of dry sample.

All procedures of this research were approved by the animal welfare committee of the animal science department of UMA University, Iran. A total of 320 one-day-old mixed sex chicks (Ross 308) were obtained from a commercial hatchery and allocated in an environmentally controlled house. The chicks were raised on a commercial starter diet and randomly divided among 20 pens (3 × 1.5 m) with wood shaving-lined floors at 11 d of age. The pens were equipped with a drinking cup and an open trough feeder. The diets were formulated to meet the nutrient requirements of Ross 308 broilers (Aviagen, 2009). All diets were fed in mash form.

Five pens per treatment were assigned to each of 4 isocaloric and isonitrogenous diets consisting of a control diet without an additional source of fibre or diets containing peanut pod at 25 g/kg (25PP), 50 g/kg (50PP) or 75 g/kg (75PP) level (Table 2). The house temperature was kept at 33 °C in the first 3 days of rearing period and then, was reduced gradually according to the age of bird until reaching 18 °C at 42 days. The broiler chickens were raised on a 23 h/daylight program. The diets were offered *ad libitum* and the birds had free access to water throughout the trial.

The body weight of broiler chickens and feed consumption were determined by pen at 11, 24, and 42 d of age for starter, grower, and finisher phases, respectively; and daily body weight gain, average daily feed intake, and feed conversion ratio were determined. The feed cost per kg live weight of experimental birds was calculated as each group feed conversion ratio (FCR) multiplied by the consumed diet price per kg and the calculated values were demonstrated as a ratio of the control group.

At 42 days of age, 2 chickens per replicate (a male and a female) were randomly selected and slaughtered. Carcass weight (without the liver and the gastrointestinal tract and its contents) was determined. The internal organs were then excised, dried with desiccant paper and weighed. The weight of the empty organs was expressed relative to live body weight. The length of the whole intestinal tract was recorded. Samples of the ileum digesta (the boundary between Meckel's diverticulum and the branching point of the cecum) immediately collected and transferred to sterile tubes and were stored at -20 °C until the tests. Ileal bacterial populations quantified using 'standard Koch's plate method'. Samples were placed in buffer peptone 1% (w/v 1:9) and then the serial dilutions were prepared. The Lactobacillus species and *E. coli* bacterial were quantified using MRS agar (MERCK, Germany) and Chromocult TBX agar (MERCK, Germany) media, respectively. All the plated in triplicates were incubated at 37 °C (Fang *et al.*, 1996).

The experiment was conducted as a completely randomized design with four dietary treatments and five replicates of 16 chicks each per treatment. One-way analysis of variance was carried out using the general linear model procedure of the SAS software (SAS Institute, 2004). Duncan's multiple range test was used to compare treatments. All differences were considered significant at $P < 0.05$.

Table 2 The ingredients and chemical composition of the experimental diets containing different levels of peanut pods

| Ingredient, g/kg | Starter | Grower | | | Finisher | | | | |
|--------------------------------|---------|---------|-------------------|-------|----------|---------|-------------------|-------|-------|
| | | Control | Peanut pod (g/kg) | | | Control | Peanut pod (g/kg) | | |
| | | | 25 | 50 | 75 | | 25 | 50 | 75 |
| Peanut pod | 0.0 | 0.0 | 25.0 | 50.0 | 75.0 | 0.0 | 25.0 | 50.0 | 75.0 |
| Corn | 459.2 | 561.8 | 532.7 | 503.6 | 474.5 | 585.8 | 556.5 | 527.4 | 498.3 |
| Soybean meal | 438.3 | 366.0 | 365.9 | 365.8 | 365.7 | 342.6 | 342.7 | 342.6 | 342.5 |
| Soybean oil | 58.8 | 32.6 | 37.0 | 41.3 | 45.7 | 35.5 | 39.9 | 44.3 | 48.6 |
| DCP | 20.9 | 15.4 | 15.5 | 15.7 | 15.8 | 14.4 | 14.5 | 14.6 | 14.7 |
| Calcium Carbonate | 11.9 | 10.9 | 10.4 | 9.9 | 9.5 | 10.4 | 9.9 | 9.5 | 9.0 |
| Common salt | 2.3 | 4.6 | 4.6 | 4.6 | 4.6 | 4.4 | 4.4 | 4.4 | 4.4 |
| Vitamin premix ¹ | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Mineral premix ² | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| DL-Methionine | 3.2 | 2.6 | 2.7 | 2.8 | 2.9 | 1.9 | 2.0 | 2.1 | 2.2 |
| HCl-Lysin | 0.4 | 1.1 | 1.2 | 1.3 | 1.4 | 0.0 | 0.0 | 0.1 | 0.2 |
| <i>Chemical analysis</i> | | | | | | | | | |
| Metabolisable energy (Kcal/kg) | 2980 | 3050 | 3050 | 3050 | 3050 | 3100 | 3100 | 3100 | 3100 |
| Crude protein | 232.7 | 213.0 | 213.0 | 213.0 | 213.0 | 203.4 | 203.4 | 203.4 | 203.4 |
| Ca | 10.33 | 8.7 | 8.7 | 8.7 | 8.7 | 8.2 | 8.2 | 8.2 | 8.2 |
| AvP | 5.2 | 4.4 | 4.4 | 4.4 | 4.4 | 4.1 | 4.1 | 4.1 | 4.1 |
| Na | 1.98 | 1.9 | 1.9 | 1.9 | 1.9 | 1.8 | 1.8 | 1.8 | 1.8 |
| Lys | 14.1 | 12.0 | 12.0 | 12.0 | 12.0 | 10.6 | 10.6 | 10.6 | 10.6 |
| Met | 6.9 | 5.8 | 5.9 | 5.9 | 6.0 | 5.1 | 5.1 | 5.2 | 5.2 |
| Met+Cys | 10.6 | 9.2 | 9.2 | 9.2 | 9.2 | 8.3 | 8.3 | 8.3 | 8.3 |
| CF | 47.0 | 44.9 | 51.8 | 60.4 | 69.5 | 43.9 | 51.9 | 58.6 | 65.4 |
| NDF | 116.1 | 114.4 | 127.0 | 149.6 | 168.7 | 114.5 | 127.0 | 149.5 | 168.8 |
| ADF | 50.1 | 48.0 | 59.5 | 61.1 | 71.9 | 46.0 | 58.1 | 69.6 | 80.5 |

¹Vitamin premix provided the following per kilogram of diet: vitamin A (retinyl acetate), 9,000 IU; vitamin D (cholecalciferol), 5,500 IU; vitamin E (dl- α -tocopheryl acetate), 68 IU; menadione, 9.0 mg; pyridoxine, 7.0 mg; riboflavin, 26.0 mg; Ca-pantothenate, 26.3 mg; biotin, 0.41 mg; thiamine, 3.66 mg; niacin, 75 mg; cobalamin, 0.03 mg; and folic acid, 3.70 mg.

²Mineral premix provided the following per kilogram of diet: Fe, 82 mg; Mn, 60 mg; Zn, 115 mg; Cu, 15 mg; I, 0.85 mg; and Se, 0.4 mg.

DCP: Dicalcium phosphate; CF: crude fibre; NDF: neutral detergent fibre; ADF: acid detergent fibre

Results

Mortality was 2.9% and was not related to experimental diets (data not shown). Data on the performance traits of broilers are shown in Table 3. The inclusion of the peanut pod in the diets decreased average daily feed intake (ADFI) of broilers at grower phase (11 - 24 d) compared to the control group ($P < 0.05$). However, at the finisher (24 - 42 d) phase only birds on the 50 PP diet consumed less feed than the control group ($P < 0.05$), and in whole the experimental period (11 - 42 d) the 25 PP and 50 PP groups consumed less feed than the control group ($P < 0.05$). The only significant difference in body weight gain (BWG) was observed in the grower phase so that the chickens fed the 75 PP diet were heavier than the control group ($P < 0.05$).

Table 3 Experiment performance characteristics of broilers fed different levels of peanut pod

| Peanut pod (g/kg) | Daily feed intake (g/b/d) | | | Daily weight gain (g/b/d) | | | Feed conversion ratio | | |
|-------------------|---------------------------|---------------------|----------------------|---------------------------|---------|---------|-----------------------|---------|---------|
| | 11-24 d | 25-42 d | 11-42 d | 11-24 d | 25-42 d | 11-42 d | 11-24 d | 25-42 d | 11-42 d |
| 0.0 | 71.58 ^a | 194.69 ^a | 140.62 ^a | 40.21 ^b | 105.10 | 76.61 | 1.78 ^a | 1.85 | 1.83 |
| 25 | 60.06 ^b | 192.01 ^a | 134.01 ^b | 40.38 ^{ab} | 105.76 | 77.07 | 1.48 ^b | 1.86 | 1.76 |
| 50 | 58.07 ^b | 180.42 ^b | 126.21 ^c | 42.05 ^{ab} | 106.85 | 77.54 | 1.43 ^b | 1.70 | 1.64 |
| 75 | 58.90 ^b | 195.37 ^a | 135.16 ^{ab} | 44.45 ^a | 104.20 | 76.26 | 1.44 ^b | 1.87 | 1.77 |
| SEM ¹ | 1.74 | 3.03 | 2.00 | 1.20 | 4.86 | 2.61 | 0.05 | 0.08 | 0.07 |

^{a,b} Within a column not sharing a common superscript differ significantly at $P < 0.05$.

¹Standard Error Mean

At grower phase, FCR improved in birds fed the diets containing peanut pod ($P < 0.05$); nonetheless, no difference was observed in the finisher phase and also the whole experimental period. All the peanut pod containing diets reduced the feed cost per kg live weight of birds in the grower phase than the control group. The same trend was observed in finisher phase with the exception of the 25 g peanut pod /kg diet (Figures 1 and 2).

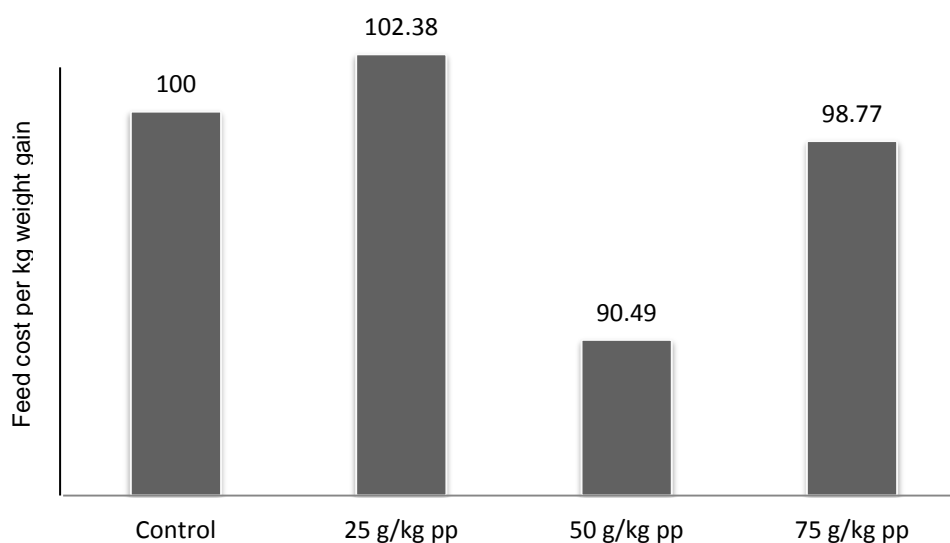


Figure 1 The feed cost per kg live weight of the broiler chickens in the grower phase as a percentage of the control group.

25 g/kg pp = The diet containing 25 g peanut pod /kg. 50 g/kg pp = The diet containing 50 g peanut pod kg. 75 g/kg pp = The diet containing 75 g peanut pod/kg.

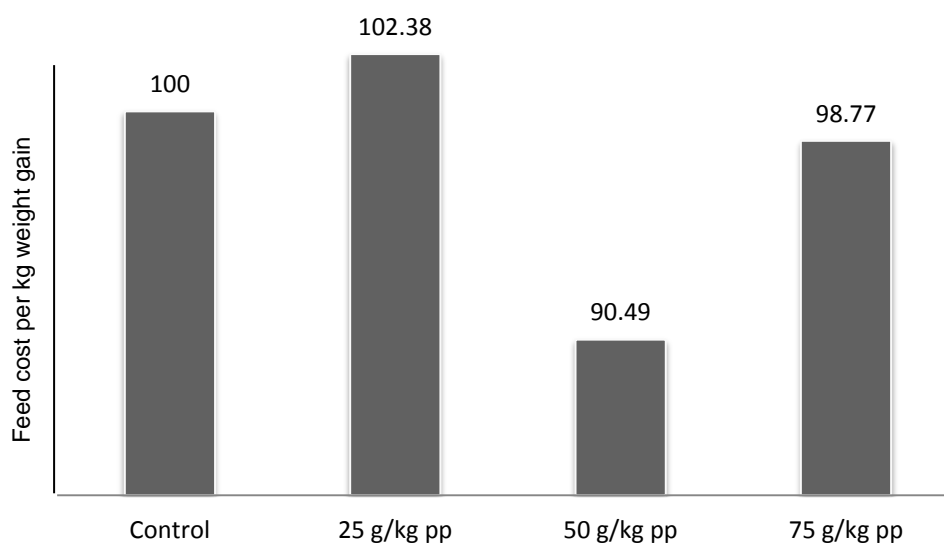


Figure 2 The feed cost per kg live weight of the broiler chickens in the finisher phase as a percentage of the control group.

25 g/kg pp = The diet containing 25 g peanut pod /kg. 50 g/kg pp = The diet containing 50 g peanut pod kg. 75 g/kg pp = The diet containing 75 g peanut pod/kg.

Table 4 shows the results of the carcass parameters of the chicks fed the experimental diets. The 75 PP diet increased carcass percentage and gizzard weights compared the chicks fed the 25 PP and the control diets ($P < 0.05$). The chickens fed the 50 PP diet showed lower abdominal fat pad deposit than the control birds ($P < 0.05$). The 75 PP diet increased total intestine length compared to the control group ($P < 0.05$). No effect of experimental diets was observed for pancreas, liver or proventriculus relative weights.

Table 4 Carcass and organ weight of experimental birds (% of live weight) fed different levels of peanut pod

| Peanut pod (g/kg) | Carcass ¹ | Pancreases | liver | Abdominal fat pad | Gizzard | Proventriculus | Whole intestine length (cm) |
|-------------------|----------------------|------------|-------|--------------------|--------------------|----------------|-----------------------------|
| 0.0 | 59.54 ^b | 2.29 | 2.19 | 2.25 ^a | 2.01 ^b | 0.40 | 201.00 ^b |
| 25 | 59.57 ^b | 2.13 | 2.10 | 1.83 ^{ab} | 2.05 ^b | 0.43 | 211.40 ^{ab} |
| 50 | 60.06 ^{ab} | 2.14 | 2.04 | 1.73 ^b | 2.29 ^{ab} | 0.38 | 216.71 ^{ab} |
| 75 | 61.27 ^a | 2.35 | 2.03 | 1.81 ^{ab} | 2.38 ^a | 0.39 | 223.89 ^a |
| SEM ¹ | 0.46 | 0.08 | 0.06 | 0.15 | 0.11 | 0.03 | 6.31 |

^{a,b}Means within a column not sharing a common superscript differ significantly at $P < 0.05$.

¹ Standard error Mean

Fibre inclusion in the diets increased pH of digesta in crop, proventriculus and, cecum compared to the control group ($P < 0.05$). However, in the gizzard and duodenum, the 75 PP diet resulted in a lower pH digesta than the 25 PP and the control groups, respectively ($P < 0.05$) (Table 5). A lower number of *E. coli* colonies were found in the ileum content of chickens fed the 75 PP diet compared the control diet ($P < 0.05$) and the Lactobacilli population in the ileum content was increased by the 25 PP diet than the 75 PP diet ($P < 0.05$) (Table 6).

Table 5 pH of gastrointestinal tract of broilers fed different levels of peanut pod

| Peanut pod (g/kg) | Crop | Proventriculus | Gizzard | Duodenum | Jejunum | Ileum | Cecum |
|-------------------|-------------------|-------------------|--------------------|--------------------|---------|-------|--------------------|
| 0.0 | 4.89 ^b | 3.63 ^b | 3.91 ^{ab} | 6.14 ^a | 6.02 | 6.50 | 7.48 ^a |
| 25 | 5.24 ^a | 4.49 ^a | 4.17 ^a | 6.02 ^{ab} | 5.93 | 6.73 | 7.01 ^b |
| 50 | 5.38 ^a | 4.27 ^a | 3.89 ^{ab} | 5.98 ^{ab} | 5.96 | 6.90 | 7.00 ^b |
| 75 | 5.35 ^a | 4.25 ^a | 3.70 ^b | 5.88 ^b | 5.93 | 6.80 | 7.22 ^{ab} |
| SEM ¹ | 0.11 | 0.13 | 0.10 | 0.05 | 0.06 | 0.21 | 0.09 |

^{a,b}Means within a column not sharing a common superscript differ significantly at $P < 0.05$.

¹Standard Error Mean

Table 6 Ileum *E. coli* and Lactobacilli populations of broilers fed different levels of peanut pod

| Peanut pod (g/kg) | <i>E.Coli</i> (log 10) | Lactobacilli (log 10) |
|-------------------|------------------------|-----------------------|
| 0.0 | 7.93 ^a | 8.42 ^{ab} |
| 25 | 7.62 ^{ab} | 8.78 ^a |
| 50 | 7.31 ^{ab} | 8.58 ^{ab} |
| 75 | 6.87 ^b | 8.17 ^b |
| SEM ¹ | 0.27 | 0.17 |

^{a,b}Means within a column not sharing a common superscript differ significantly at $P < 0.05$.

¹Standard Error Mean

Discussion

In this study, dietary peanut pod as a source of the lignocellulosic compound at 75 g/kg level improved body weight gain of broilers at grower phase. However, this situation was changed at the finisher phase such that, during the experimental period, no differences were observed in the daily weight gain of experimental birds. This finding suggests that the dietary fibre effect on chicks' performance will change with gastrointestinal development and a coarse dietary fibre source seems more effective in younger birds. This observation also indicates that broilers need a minimal dietary insoluble fibre in the diet to maximize growth performance. These observations are in agreement with the results of Gonzalez-Alvarado *et al.* (2010) and Mateos *et al.* (2012) who found that the moderate levels of dietary insoluble fibre improved the growth performance of broilers.

In practice, broilers eat to gut fill (Ferket & Gernat, 1996) since feed intake is determined mostly by the physical capacity of the gastrointestinal tract (Nir *et al.*, 1996). Previous studies have suggested that dietary insoluble fibre will increase the passage rate of the digesta through the distal part of the gastrointestinal tract and hence promote higher feed intake (Montagne *et al.*, 2003; Hetland *et al.*, 2004), a situation which was not observed in the present study.

Singh and Narang (1991) suggested that there is a positive correlation between water holding capacity (WHC) and NDF content of the feed. On the other hand, broiler feed intake is usually a function of their gut physical capacity and because of the higher NDF (and WHC) of the peanut pod containing diets, they may not be able to adapt their feed intake to meet required dry matter. These may explain the lower daily feed intake of the chickens fed the peanut pod in this study.

However, it has been proved that broilers eat mainly to meet their energy needs; and dietary energy dilution because of inclusion of an insoluble fibre source in the diet will result in a higher feed intake (Ferket and Gernat, 1996). But, unlike the majority of the preceding studies, in this research, the fibre source was used to formulate isocaloric experimental diets and was not added as an additive and diluting factor.

In the current study, 75 g/kg dietary inclusion of peanut pod increased the total intestine length and gizzard weight. Inconsistent with these observations, Jorgensen *et al.* (1996) showed that the size of the gastrointestinal tract increased by inclusion in the diet of an insoluble fibre source (oat bran). Especially inconsistent with our observation, the effect of dietary insoluble fibre on increasing the gizzard weight in broilers has been reported using Vitacel (JRS Co. Inc., Rosenberg, Germany), a commercial source of insoluble dietary fibre (Rezaei *et al.*, 2011), wood shavings (Hetland *et al.*, 2003), oat hulls (Gonzalez-Alvarado *et al.*, 2008), and pea hulls (Jimenez-Moreno *et al.*, 2013).

In some other reports, the 10% dietary oat hulls have been found to increase wheat starch digestibility and stimulate gizzard activity in broilers (Rogel *et al.*, 1987; Hetland & Svihus, 2001). Additionally, Hetland *et al.* (2003) reported increased bile acids in the gizzards of birds fed wood shavings. Sacranie *et al.* (2012) used 150 g/kg coarse hulls from oats and barley and found that the weight gain and the FCR of broilers were not affected. They attributed it to the increased starch digestibility.

The coarse fibre particles are kept in the gizzard until they are ground to a particular critical size that allows them to pass through the pyloric sphincter (Clemens *et al.*, 1975; Moore, 1999; Hetland *et al.*, 2003). This leads to an enlargement of the organ and a muscular adaptation to meet the higher demand for grinding. Hetland *et al.* (2003) reported that the mean particle size of oat hulls in the duodenum of chickens was between 120 and 127 μm . They also suggested that 90% of duodenal particles are less than 300 μm and hulls, ground through a 1-mm sieve were coarse enough to be kept in the gizzard as a grinding medium (Hetland *et al.*, 2001). This observation was repeated using a 2 mm sieve size with peanut pod in this study. In the research of Jimenez-Moreno *et al.* (2011), 25 g pea hulls /kg and in the study of Jimenez-Moreno *et al.* (2013) 75 g/kg oat husks in diet, decreased the pH of gizzard content which is agreed with the effect of 75 PP than the 25 PP diet in this study. The longer presence of feed in gizzard stimulates hydrochloric acid secretion in the proventriculus (Duck, 1986).

The results of the present study showed that using peanut pod as a lignocelluloses source in broiler diet could reduce the population of *E. coli* in the ileum. In a comparable report, it was shown that 4% alfalfa meal in the broiler diet, reduced the number of *E. coli* compared with the control group (Tkáčová & Angelovičová, 2013). There are more previous reports on the positive effect of lignocellulose on gut *Bifidobacterium*, and *Lactobacillus* (Cao *et al.*, 2003). The mechanism of lignocelluloses effect on the gastrointestinal tract bacteria is not completely understood. The friction effect of lignocelluloses compounds on the surface of the gastrointestinal tract, help to remove pathogenic bacteria from the mucous layer (Mateos *et al.*, 2012). This effect, in turn, encourages the proliferation of beneficial microflora. These microorganisms release bacteriocins, which decrease the proliferation of pathogens in the gut (O'Shea *et al.*, 2012). Furthermore, polyphenolic compounds of lignin might cause a split in the membrane of the bacterial cell and hence reduce the pathogen growth in the digestive tract (Baurhoo *et al.*, 2008).

Vitacel (JRS Co. Inc., Rosenberg, Germany) is a commercial source of insoluble dietary fibre and many other important seeds, such as oats, barley, pea, and soybean have a considerable quantity of hulls which could be used as a source of insoluble fibre in broiler diets. In some reports, the 10% dietary oat hulls have been found to increase wheat starch digestibility and stimulate gizzard activity in broilers (Rogel *et al.*, 1987; Hetland & Svihus, 2001). Additionally, Hetland *et al.* (2003) reported increased bile acids in the gizzards of birds fed wood shavings. Sacranie *et al.* (2012) used 15 g coarse hulls /kg of oats and barley and found that the weight gain and the feed conversion ratio of broilers were not affected. They attributed it to the increased starch digestibility.

Conclusion

This study showed that including peanut pod as lignocelluloses compound positively influenced broiler performance at grower phase. It seems that the diets of broilers should be formulated to provide adequate insoluble fibre, so that the results suggest that the 75 g/kg dietary peanut pod was more effective to promote broiler growth performance, especially at the grower phase. The optimistic effect of dietary peanut pods in this study was probably because of an improvement in digestive capacity and bacteria populations of the gastrointestinal tract. On the other hand, the calculations in the current study showed that the feed cost per kg weight gain of broilers was reduced with peanut pod contained diets particularly, at the 50 g/kg level. This finding suggests that the economic income has to take into account while evaluating the dietary fibre effects. Because of the low cost and availability of peanut pod as a by-product, it could be a good alternative to commercial insoluble fibre products such as VITACEI.

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Authors' Contributions

BN and ES were in charge of the experimental design. BN wrote the manuscript. Revisions of the manuscript were performed by FMA.

Conflict of Interest Declaration

There are no conflicts of interest.

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