Performance and microbial status of turkeys fed diets containing different levels of inulin*

Leistung und mikrobieller Status von Puten bei Fütterung von Rationen mit unterschiedlichen Inulin-Gehalten

J. Juskiewicz1, J. Jankowski2, Z. Zdunczyk1, El. Biedrzycka1 and A. Koncicki3


Introduction

Fructan-type oligosaccharides are not digested in the small intestine, since the poultry endogenous secretions lack the enzymes to hydrolyze them. The undigested fructans reach the caeca where they interact with the microbial flora (Lii and Tveey, 1998). Some studies on birds have shown that when used in limited amounts in feed (below 0.5%) fructo-oligosaccharides may result in an improvement in the production status (Wu et al., 1999), whereas others have reported no body weight gain responses to fructo-oligosaccharide in diets for birds (Waldroup et al., 1993; Durst, 1996; Juskiewicz et al., 2002). An increasing number of authors have been suggesting that feeding poultry a diet supplemented with fructan-type oligosaccharides may lead to a shift in the intestinal gut microflora and that these diet-ingredients have been implicated in increasing the densities of beneficial bacteria (bifidobacteria, lactobacilli) as well as the reduction of the ability of harmful species to grow and colonize the gut (Bailey et al., 1991; Fukata et al., 1999). Oyarzabal et al. (1995) concluded that fructo-oligosaccharides in poultry feeding may serve as a fermentative substrate for the growth of beneficial microflora that would generate adverse conditions for harmful bacteria (e.g. Salmonella) colonization.

The usage of antibiotics for growth promotion in poultry has been banned in many countries, therefore prebiotics, like fructooligosaccharide-products (FOS), have the potential to reduce enteric disease in poultry and subsequent contamination of poultry products (Patterson and Burkholder, 2003). For this reason, an interest in the addition of fructan-type saccharides (inulin and oligofructose) to a diet for poultry, considered a factor potentially beneficial to control gut microflora (e.g. Escherichia coli), was formulated to meet the nutrient requirements for turkey and it was changed every four weeks. In a control diet, a premix without an antibiotic and inulin was applied. The experimental diet contained flavamycin (8 mg/kg) or low (L), medium (M) or high (H) level of commercially available inulin preparation (Frutafit-Inulin Tex, Netherlands).

The experiment lasted 16 weeks. After that the birds were weighed and 8 turkeys from each group were killed according to the recommendations for euthanasia of experimental animals (Close et al., 1997). As soon as possible after euthanasia the caeca were removed and weighed, and the caecal pH was measured using a microelectrode and a pH/ION meter (model 301, Hanna Instruments). Samples of caecal digesta were transferred to microfuge tubes which were immediately stored at –40°C.

Caecal digesta were also measured for short-chain fatty acid (SCFA) content by gas chromatography (Shimadzu GC-14A with a glass column 2.5 m × 2.6 mm, containing 10% SP-1200/1% H3PO4 on 80/100 Chromosorb W AW, column temperature 110°C, detector FID temperature 180°C, injector temperature 195°C). The samples of digesta were weighed, mixed with 0.2 mL of formic acid, diluted with deionised water and centrifuged at 10000 × g for 5 min. Supernatant was decanted for injection in the gas chromatograph. Caecal SCFA pool size was calculated as the product of SCFA concentration in digesta and caecal digesta mass.

Three groups of microflora, Bifidobacterium, Lactobacillus and Escherichia coli, were determined in the caecal contents. All bacterial determinations were done immediately after sampling. The samples were treated and the counts of Bifidobacterium and Lactobacillus were deter-

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mined according to the procedure described earlier (BIE-DRZYCKA et al., 2003); and E. coli counts were determined on MacConkey Purple agar medium (1 L of distilled water contained: 20 g peptone-tryptone, 10 g lactose, 5 g bacteriological bile, 5 g sodium chloride, 0.07 g bromocresole purple; pH 7.4 ± 0.1), after 24 h incubation at 37°C. The microbiological results were expressed as log colony forming units cfu/g caecal contents.

The results of the experiment were analyzed using the one-way ANOVA test, and significant differences between groups were determined by the Duncan’s multiple range test (STATISTICA software, StatSoft). Differences were considered significant at P ≤ 0.05 and P ≤ 0.01.

Results

The feed intake was similar in all groups examined during the entire experiment (Table 2). The live body weight of birds during 16 weeks of feeding varied between the treatment groups. At 4 weeks of age, the average body weight of turkey in the Inulin-M group (0.98 kg) was significantly higher (P ≤ 0.05) than in the Inulin-H group (0.91). The remaining treatments were intermediate between them. At 8 weeks of age, the birds from the Inulin-M and control groups were the heaviest (4.01 and 3.96 kg, respectively) and the turkeys from the Inulin-H were the lightest (3.74), with statistical differences noted at P ≤ 0.05. There were no significant differences between groups in live body weight at the age of 12 weeks. At the termination of the experiment (16 weeks), the turkeys fed a diet containing the highest dose of inulin preparation were the lightest (13.23 kg), and differed especially compared to the control group (13.82 kg, P ≤ 0.01) and to the Inulin-L group (13.77 kg, P ≤ 0.05). The birds from the antibiotic and Inulin-M groups weighed 13.51 and 13.50 kg, respectively.

The feed conversion ratio (FCR) did not differ significantly among all treatments during the entire experiment, however the control was the best one and Inulin-H was the worst one.

As shown in Fig. 1, a decrease (but without statistical confirmation) in pH of the caecal digesta was observed

Table 1. Composition of experimental diets with different premix (without or with antibiotic) and low (L), medium (M) or high (H) level of inulin (%)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>Flavomycin</th>
<th>Inulin-L</th>
<th>Inulin-M</th>
<th>Inulin-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 1-4 weeks, kg/turkey</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>at 5-8 weeks, kg/turkey</td>
<td>5.8</td>
<td>5.9</td>
<td>6.0</td>
<td>6.1</td>
<td>5.8</td>
</tr>
<tr>
<td>at 9-16 weeks, kg/turkey</td>
<td>25.8</td>
<td>25.3</td>
<td>25.9</td>
<td>25.6</td>
<td>25.8</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 4 weeks</td>
<td>0.96ab</td>
<td>0.95ab</td>
<td>0.94ab</td>
<td>0.98a</td>
<td>0.91b</td>
</tr>
<tr>
<td>at 8 weeks</td>
<td>3.96a</td>
<td>3.92ab</td>
<td>3.94ab</td>
<td>4.01a</td>
<td>3.74b</td>
</tr>
<tr>
<td>at 12 weeks</td>
<td>8.33</td>
<td>8.13</td>
<td>8.36</td>
<td>8.11</td>
<td>8.16</td>
</tr>
<tr>
<td>at 16 weeks</td>
<td>13.82Aa</td>
<td>13.51Aab</td>
<td>13.77ABAa</td>
<td>13.50ABAab</td>
<td>13.23ABb</td>
</tr>
<tr>
<td>FCR, kg/kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 1-4 weeks, kg</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>at 5-8 weeks, kg</td>
<td>1.9</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>at 9-16 weeks, kg</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

1 Flavomycin (8 mg/kg diet)
2 Two diets for the 1-4 and 5-8 weeks of feeding containing (calculated analysis on basis of air dry feed): crude protein – 26.5 and 25.6%, ME – 11.7 and 11.9 MJ/kg, crude fibre – 3.4 and 3.3%, L-lysine – 18.1 and 16.5 g/kg, DL-methionine + cysteine – 10.6 and 10.7 g/kg, calcium – 12.8 and 12.3 g/kg, phosphorus available – 7.21 and 6.89 g/kg, nitrogen – 1.55 and 1.55 g/kg, selenium – 0.3 and 0.3 mg/kg, vitamin A – 15000 and 13000 IU/kg, vitamin E – 40 and 35 mg/kg, respectively.
3 Two diets for the 9-12 and 13-16 weeks of feeding containing (calculated analysis on basis of air dry feed): crude protein – 22.9 and 18.8%, ME – 12.7 and 12.8 MJ/kg, crude fibre – 3.1 and 3.0, L-lysine – 13.95 and 11.95 g/kg, DL-methionine + cysteine – 9.79 and 7.25 g/kg, calcium – 11.92 and 10.11 g/kg, phosphorus available – 6.65 and 5.03 g/kg, nitrogen – 1.51 and 1.57 g/kg, selenium – 0.2 and 0.3 mg/kg, vitamin A – 12000 and 12000 IU/kg, vitamin E – 30 and 30 mg/kg, respectively.
when an increased dose (medium and high) of inulin was used in the diet (6.84 and 6.92, respectively), compared to the Inulin-L group (7.12). The addition of an antibiotic to a diet caused an insignificant increase in pH of the caecal digesta (7.09) compared to the control turkeys (6.88).

Compared to the control group, the addition of an antibiotic to a diet slightly increased the total content of SCFAs produced in the caeca (70 and 80 µmol/kg BW, respectively), without changes in C2:C3:C4 profile (Fig. 2 and Fig. 3). The production of short-chain fatty acids in the caeca of turkeys fed diets supplemented with inulin was relatively low, especially in the Inulin-L and Inulin-M groups (57.6 and 64.2, respectively), while the Inulin-H group had the greatest SCFAs pool (89.8) of all the treatment groups. When the C2:C3:C4 profile is considered, smaller doses of inulin (low and medium levels) evoked a lowering effect on acetate and an opposite effect on propionate and butyrate percentage in that profile. In the group with the highest inulin addition, the C2:C3:C4 profile was similar to that of the control group.

In the control group of turkeys, the Bifidobacterium and Lactobacillus counts varied substantially within inulin groups. Low and medium doses of inulin resulted in lower mean Lactobacillus counts, 8.64 ± 0.27 and 8.44 ± 0.41 log cfu/g, respectively, showed also an increasing tendency. A significant increase in Bifidobacterium count by ~0.9 (P ≤ 0.05) was observed in the Inulin-H group versus the antibiotic-administered one. Lactobacillus counts varied substantially within inulin groups. Low and medium doses of inulin resulted in lower mean Lactobacillus counts, 8.64 ± 0.27 and 8.44 ± 0.41 log cfu/g, respectively, with significantly lower (P ≤ 0.05) counts for the latter in comparison to the control. However, when high doses of inulin were administered, the Lactobacillus counts were 8.92 ± 0.52 log cfu/g, i.e. reached the same level as in the control. Populations of E. coli in all groups receiving inulin, 5.40 ± 0.43 (Inulin-L), 6.01 ± 0.58 (Inulin-M) and 5.34 ± 0.17 log cfu/g (Inulin-H), decreased significantly by ~0.8-1.5 log cycle (all P ≤ 0.01) in comparison to the control, however, to a higher extent in the Inulin-L and Inulin-H groups, than in the Inulin-M group.

Discussion

The experimental treatments did not influence the feed intake nor the feed conversion ratio, but there were few differences in growth performance between the groups. At the age of 4 as well as 8 weeks, the heaviest were the turkeys from the Inulin-M group and the lightest – those from the Inulin-H one. At the termination of the experiment (16 weeks of age), the birds fed a diet containing the highest...
dose of inulin remained the lightest, whereas the control birds had the greatest average live weight. The live body weight of turkeys from the antibiotic group during the entire feeding period was on a medium level among treatment groups. The obtained results indicate that neither the antibiotic (flavomycin) nor inulin addition acted as a growth promoter in the presented study. In our previous short-term (4-week) study on young turkeys fed diets supplemented with 0.4% of different oligosaccharides (mannan-oligosaccharide, fructo-oligosaccharide, inulin), no significant differences were found in feed intake, feed conversion nor final body weight between experimental groups (Juskiewicz et al., 2002). In studies on poultry, low-digestible oligosaccharides have generally been shown to have a positive, although not always significant, effect on bird performance. For example, in the study of Durst (1996), no significant increase was reported in the average daily weight gain upon the addition of fructans (fructo-oligosaccharide, 0.2%) in broiler diets. On the other hand, opposite effects of fructan implementation to broiler diets were found in the study of Wu et al. (1999), where the FOS level in the optimal level of inulin addition quadrupled the body weight gain and feed efficiency. Other factors such as stress, subclinical disease, or diet inadequacy may influence the efficacy of oligosaccharides on poultry performance. It has been also reported that administration of an antibiotic had no significant effect on live body weights of healthy poultry (Bilal et al., 2000; Izat et al., 1989).

Moreover, Patterson et al. (1997) claimed that when the improvement of health status is considered, prebiotics are the most effective when the animal's resistance to pathogens is lowered by stress, such as poor environmental conditions, and that one may not see an effect on performance in relatively healthy, unstressed animals. The main action of low-digestible carbohydrates in the gastrointestinal tract of poultry is mainly associated with the caeca ecosystem and SCFAs (short-chain fatty acids) production (In and Tivey, 1998). Oligosaccharides are thought to act by altering large intestine environment, then microbial populations and functions. The caecal response to the experimental treatments used in this study is described in detail in the paper by Juskiewicz et al. (2004), where the authors reported that the caecal tissue weight was not significantly different among all groups. There were also no significant differences in the amount of caecal digesta, however the amount of digesta in the caeca was noticeably greater in the Inulin-H group, compared to the turkeys fed with both lower levels of inulin and antibiotic supplementation as well. The smallest amount of digesta in the caeca was noticed in the control group. The lack of significant differences was due to a high diversity of results in each experimental group. One of the most important indicators of caecal status, the pH of caecal digesta, was on a similar level in the control group and groups fed with medium and high dose of inulin, whereas the antibiotic as well as an extremely low inulin level caused a slight raise of pH range. Some authors showed that principally lower pHs of digesta are responsible for the proliferation of beneficial bacteria and under such conditions, potential detrimental bacteria may be displaced by bifidobacteria (Gibson et al., 1995; Oyarzabal and Conner, 1996). We have already shown that in this experiment the protein pool in the caecal digesta, expressed as mg/kg BW, was greater when more inulin preparation was used in the diet and that suggested an intensification of bacterial proliferation on the caeca of turkeys (Juskiewicz et al., 2004). The concentration of short-chain fatty acids estimated in the caeca of turkeys was affected to some extent by other parameters of the gut function (i.e. amount of digesta and degree of its hydration). Therefore, the calculated total SCFAs pool produced in the caeca provides more precise information on the effect of the investigated preparation on the fermentation in the gut. The greatest production of SCFAs (not different statistically from control and antibiotic groups) was found in the turkey fed with the high level of inulin, which is in accordance with the suggestion that oligosaccharide inclusion to a diet is likely to promote SCFA production (In and Tivey, 1998). The results obtained from the Inulin-L and Inulin-M groups were very surprising, because of a very low SCFA pool in those groups compared to the control birds. In our previous study on young turkeys (Juskiewicz et al., 2002), the 4-week feeding with 0.4% inulin supplementation gave greater SCFAs pool, compared to the control birds or diets containing commercially available fructo-(FOS) and mannan-oligosaccharides (MOS). In the present study, the composition of the major short-chain fatty acids, despite some differences in groups with small and medium doses of inulin (less acetate, more propionate and butyrate, compared to the remaining treatments), was in agreement with the results of Terada et al. (1992) that at all administration levels the beneficial acetate to propionate ratio is predominating, followed by butyric and propionic acid.

Subtherapeutic doses of antibiotic growth promoters have been widely used in broiler production for protection against enteric pathogen infections. However, they do not lower merely pathogen populations but overall intestinal bacteria, thus maintaining artificially-altered equilibrium of microflora, as well as weaken the natural protection secured by the immune system. Facing restricted antibiotic use as growth promoters, leaving the poultry without protection would be a real disaster. The observed side effects of antibiotic withdrawal in the EU were associated with deterioration in animal health (increased diarrhoea, weight loss and mortality due to Escherichia coli and Lawsonia intracellularis, clostridial necrotic enteritis), and resulted in an increased usage of therapeutic antibiotics in food animals, including those important in human medicine (Cawsewell et al., 2003). The route of antibiotic action was confirmed in the present study, as flavomycin reduced the levels of all bacterial counts determined, no matter favourable or not. The previous studies on the supplementation of a diet with avilamycin as a growth promoter in turkeys resulted in some negative changes of microflora, e.g. a significant increase in E. coli populations under administration, and significantly decreased counts of Bilidobacterium and Lactobacillus at the end of antibiotic withdrawal period (Bierczynska et al., 2003). In the studies of Kwaardorp et al. (2002), avilamycin and salinomycin used as growth promoters for broiler chickens affected most strongly ileal populations of lactobacilli and Clostridium perfringens.

Therefore, searching for the nutrient feed supplement selectively stimulating the populations of groups of intestinal microflora beneficial for host's health and capable of controlling the other populations seems to be necessary and reasonable. Prebiotics are well-known agents fulfilling those criteria (Gibson and Roberfroid, 1995). The effectiveness of fructans was proved in animal and human studies, however they have not been used for poultry so far, most likely because of economic reasons. In the present study, use was made of inulin Frutafit Tex (Sensus, the Netherlands), a long-chain, sugar-free inulin, with good gelling and texturing properties. Low polymerised fructans (fructooligosaccharides, oligofructose and mildly-polymerised inulins) are however more willingly utilised in vitro by bifidobacteria than highly-polymerised inulins. Still promising bifidogenic activity of highly-polymerised inulins in vivo has been reported, however dependent on the
presence and ability of other bacteria to initiate inulin degradation (Biedrzycka and Bielecka, 2004).

Low and medium doses of inulin appeared to be insufficient for the stimulation of Bifidobacterium growth, however the mean counts were slightly higher than in the control. When oligofructose (DP, degree of polymerization 2-9) was administered to healthy human subjects for 11 days at low intake levels, 5 g/d., an increase in bifidobacteria numbers by almost one log cycle was observed, along with an increase in the counts of total anaerobes and Bacteroides, whereas the populations of total aerobes and coliforms remained unaffected (Rao, 2001). Unfortunately, in our study, long-chain inulin was not an easily available substrate for lactobacilli, and their counts were slightly (Inulin-L) or significantly (Inulin-M) decreased. The preferential utilisation of fructans by bifidobacteria vs. lactobacilli was shown in vitro by Markowska et al. (2003). In their study, FOS (fructo-oligosaccharides) and Raftilose Synergy 1 (oligofructose) stimulated growth of all 13 strains of Bifidobacterium by 1.0-4.8 and 1.0-3.7 times, respectively, and all 7 and 4 out of seven strains of Lactobacillus by up to 1.1-3.8 and 1.1-1.8 times, respectively.

In the present study, the E. coli counts, as markers of opportunistic bacteria, were also significantly decreased in comparison to the control, moreover, to much higher extent than in the antibiotic-administered group. Low and medium doses of inulin were generally too low to induce any bacterial stimulation, and resulted in lower Lactobacillus populations. That was perhaps the reason for a significantly higher level of E. coli in the Inulin-M than the Inulin-L group. The highest doses of inulin affected microflora most positively - the populations of Bifidobacterium were increased by 1.0-4.8 and 1.0-3.7 times, respectively, and all 7 and 4 out of seven strains of Lactobacillus by up to 1.1-3.8 and 1.1-1.8 times, respectively.

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It is difficult to compare the effectiveness of inulins with the results of other authors. A few promising studies on the application of FOS for Salmonella control were undertaken (Oyarzabal and Conner, 1996; Chambers et al., 1997), whereas the research on inulins as feed supplements for poultry and their impact on normal caecal microflora are scarce. When broiler chickens were fed the crude thermal kestoses (2% kestoses, 8% other sugars) for 11 weeks, it was observed, along with an increase in the counts of total anaerobes and Bacteroides, whereas, in comparison with the control, caecal bifidobacterial concentrations were increased by ~1.4 log cycle (10.36 vs. 8.98 log cfu/g caecal DM, P < 0.001), and anaerobically enumerated lactobacilli concentrations were increased by ~0.9 log cycle (10.43 vs. 9.56 log cfu/g caecal contents, P < 0.007 (Patterson et al., 1997).

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Summary

The goal of this study was to examine the effect of diet enrichment with different levels of inulin (0.1 to 1.0%) on the performance and microbial status of turkeys. For 16 weeks, turkeys were fed the following diets: control without antibiotic or inulin, diet with flavomycin (8 mg/kg), and diets containing different levels of inulin: low (0.1% for 16 weeks), medium (0.4% and 0.2% in the first and second 8-week period, respectively) and high (1% and 0.4% in the first and the second 8-week period of the experiment, respectively). The feed intake and feed efficiency ratio were not statistically different in all groups examined during the entire experiment. At the termination of experimental feeding, the turkeys from the Inulin-H group were the lightest (13.23 kg), and differed especially compared to the control group (13.82 kg, P ≤ 0.01) and to the Inulin-L (low) group (13.77 kg, P ≤ 0.05). The birds from the antibiotic and Inulin-M groups weighed 13.51 and 13.50 kg, respectively. The administration of an antibiotic and a low dose of inulin resulted in overall reduction of caecal bacterial populations in comparison to the control and Inulin-M and Inulin H-group. Flavomycin significantly decreased E. coli counts by 0.5 log cycle (P < 0.05) and tended to lower Bifidobacterium and Lactobacillus populations compared to the control turkeys (8.44 vs. 8.80 and 8.58 vs. 8.85 log cfu/g, respectively). All doses of inulin effectively reduced E. coli populations by 0.8-1.5 cycle (P < 0.01) in comparison to the control group. The greatest reduction was observed in the Inulin-H group, accompanied by an insignificant but noticeable increase in Bifidobacterium and Lactobacillus counts and the greatest short-chain fatty acids production, however the final body weight of the birds from that group was lower than in other treatment groups. Compared to the control and antibiotic groups, the low and medium contents of inulin in a diet had no influence on turkey performance. The results indicate that the supplementation of diets with inulin can improve microbial status of turkeys.

Key words

Turkey, inulin, performance, caeca, caecal microflora

Zusammenfassung

Leistung und mikrobieller Status von Puten bei Fütterung von Rationen mit unterschiedlichen Inulin-Gehalten

In der vorliegenden Untersuchung sollte überprüft werden, inwieweit sich eine Zulage an unterschiedlichen Mengen an Inulin zu den Futtermitteln (0.1 bis 1,0%) auf die Leistung und den mikrobiellen Status von Puten auswirkt. Die Puten wurden hierzu über 16 Wochen mit folgenden Rationen gefüttert: Flavomycin (8 mg/kg), Low Inulin (0,1% über 16 Wochen), Medium Inulin (0,4% in den ersten 8 und 0,2% in den zweiten 8 Wochen) und High Inulin (1% in den ersten 8 und 0,4% in den zweiten 8 Wochen). Über die gesamte Versuchsduar konnten weder für die Futtermängelhaft noch für die Futterverwertung signifikante Unterschiede zwischen den Behandlungen beobachtet werden. Am Ende der Versuchsduar waren die Puten der Behandlung High Inulin am leichtesten (13,23 kg) und unterschieden sich signifikant von der Kontrollgruppe (13,82 kg, P ≤ 0,01) und der Low Inulin Gruppe (13,77 kg, P ≤ 0,05). Die Tiere der Behandlungen Flavomycin und Medium Inulin wogen 13,51 bzw. 13,5 kg. Die Verabreichung des Antibiotikums und der geringen Dosis an Inulin führten zu einer Verminderung der Bakterienpopulationen im Blinddarm im Vergleich zur Kontrolle und zu den Behandlungen Medium Inulin und High Inulin. Flavomycin reduzierte signifikant die E. coli Keime bei 0,5 log Einheiten (P ≤ 0,05) und reduzierte in der Tendenz im Vergleich...
zur Kontrolle die Bifidobacterium- und Lactobacillus-Populationen (8,44 zu 8,80, 8,58 zu 8,85 log cfu/g). Alle Zulagen an Inulin reduzierten im Vergleich zur Kontrolle die E. coli-Populationen bei 0,8-1,5 log (P ≤ 0,01) effektiv. Die größte Reduzierung wurde in der Behandlung High Inulin registriert, bei einer gleichzeitigen, wenn auch nicht signifikanten Zunahme der Bifidobacterium- und Lactobacillus-Zahlen. Ferner lag hier auch die höchste Produktion an kurzkettigen Fettsäuren vor. Jedoch war das Körperfekt von dieser Behandlung geringer als das der anderen. Im Vergleich zur Kontrolle und der Antibiotika-Behandlung hatten die geringer und mittleren Gehalte an Inulin in der Vergleich zur Kontrolle und der Antibiotika-Behandlung geringer als das der anderen. Im Vergleich zur Kontrolle und der Antibiotika-Behandlung hatten die geringer und mittleren Gehalte an Inulin in der Ration keinen Einfluss auf die Leistung der Puten. Die Ergebenisse zeigen, dass durch den Einsatz von Inulin im Fut ter der mikrobielle Status der Puten verbessert werden kann.

Stichworte
Pute, Fütterung, Inulin, Leistung, Blinddarm, Mikroflora

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