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Performance and gastrointestinal responses of turkeys to different levels of enzyme (xylanase and glucanase) in a diet

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Summary

The aim of study was to evaluate the use of different levels of NSP degrading blend of enzymes (β-xylanase and β-glucanase) in practical wheat/barley-based diets for growing turkeys. The growth performance, as well as intestinal metabolism indicators of BIG-6 female turkeys was measured during the 8 weeks of experimental feeding. Turkeys were fed diets without enzyme supplementation (control group) or diets supplemented with enzyme preparation applied at doses of 50 (low), 100 (medium) and 150 mg/kg diet (high). The feed enzyme preparation contained a blend of xylanase (210 000 U/g) and β-glucanase (130 000 U/g of product). In the growth trial, enzyme supplementation did not significantly affect the body weight of the turkeys. The highest dose (150 mg/kg) of enzyme preparation decreased ($p \leq 0.05$) ileal viscosity (2.42 vs. 2.66 mPa.s), caecal viscosity (9.12 vs. 11.36 mPa.s), and weight of small intestinal tissue (10.6 vs. 13.4 g/kg BW) and feed conversion ratio of trial turkeys (by 3.5%) in comparison with the control animals. Enzyme supplementation also caused a visible growth tendency in total VFA in the caecal digesta of the turkeys. The proportions of major fatty acids also changed compared with the control group and the production of acetic acid increased, whereas the production of propionic acid decreased. No enzyme addition response was observed for lactic acid bacteria, Enterobacteriaceae, Escherichia coli or Clostridium perfringens rods in caecal digesta of turkeys, but the aerobic spore forming bacteria count decreased ($p \leq 0.05$). The best performance and physiological response of turkeys was obtained after applying the highest proportion (150 mg/kg) of enzyme preparation to the diet.

Keywords: non-starch polysaccharides, exogenous enzymes, growth performance, turkeys

Variation in concentration of non-starch polysaccharides (NSP) of wheat, triticale, barley and rye has the influence on *in vitro* cereal extract and intestinal viscosity in broilers (5, 8, 19). Increase in small intestine viscosity in broilers have been shown to reduce nutrient digestibility, metabolizable energy and performance (5, 19) and to increase the small intestine populations of some microbial groups (7, 25). Furthermore, soluble NSP were shown to influence gut morphology and mucosal cell turnover. Feeding high concentrations of soluble NSP was found to increase the length, the absolute and relative weight of small intestine as well as to increase the rate of intestinal cell division in broilers (15, 22, 26). The use of NSP-hydrolyzing enzymes as feed additives have been proven as effective tools in countering the gel-forming properties of soluble NSP (6, 12, 13). Supplementing the cereal-based diets with NSP-degrading carbohydrases, capable of hydrolyzing endosperm cell walls, may improve dietary nutrient availability by degrading the xylan and glucan into smaller units which reduce the viscosity of the digesta in the small intestine (16). Reduced digesta viscosity in this intestine improves the rate of diffusion between substrates and endogenous enzymes and decreases the proliferation of the microbiota, enabling the bird to digest and absorb more nutrients (6, 13).

However, recent evidence suggests that the positive responses from enzyme supplementation are not always associated with a decrease in digesta viscosity

(8). The physical entrapment of wheat/barley starch and protein by cell wall polysaccharides has been suggested as another important factor by which NSP exert their antinutritive properties (12, 17).

The study was conducted to evaluate the use of different levels of NSP degrading blend of enzymes (xylanase and β-glucanase) in practical wheat/barley-based diets for growing turkeys. The growth performance, as well as the intestinal metabolism indicators of turkeys were estimated after 8 weeks of experimental feeding to study the possible mechanism for a potentially enhanced growth performance in turkeys.

Material and methods

Animals and diets. The experiment was conducted at the State Turkey Evaluation Station of the Warmia and Mazury University (Olsztyn, Poland) according to the guidelines of the Local Animal Experimentation Ethics Committee at university.

A total of 1000 one-day-old heavy Large White BIG-6 female turkeys, sexed at the local commercial hatchery, were randomly assigned to four dietary treatments of five replications each. The birds had free access to control diet without any growth promoter or antibiotic (control group) or to the diets supplemented with an enzymatic preparation in the amounts of 50, 100 and 150 g/t (group K1, K2 and K3, respectively). Fresh drinking water was supplied *ad libitum* by a bell-type drinker. All feed mixtures were formulated using least-cost linear programming software to meet the nutrient requirements for turkeys, according to National Research Council recommendation (1). The composition and nutritive value of diets are given in tab. 1. Phase starter diets were offered as crumbles and grower diets as 3 mm pellets.

The feed enzyme combination contained standardized activities of endo-1,4-β-xylanase (210 000 units per gram of product) (3.2.1.8.), endo-1,3(4)-β-glucanase (10 000 U/g) (3.2.1.6.), endo-1,4-β-glucanase (120 000 U/g) (3.2.1.4.), as well as a small concentration of α-amylase (400 U/g) (3.2.1.1.). One unit of xylanase activity is defined as the activity required to liberate 1 µg of xylose equivalents per minute from a 0.5% xylan solution at pH 5.3 and 50°C. One unit of β-glucanase activity is defined as the activity required to liberate 1 µg of reducing sugar (measured as glucose equivalents) per minute from a 0.5% β-glucan solution at pH 7.5 and 30°C. The levels of the xylanase in the enzyme-supplemented feed were 10 500, 21 000 and 31 500 U/kg, respectively, and the actual levels of the β-glucanase were 6500, 13 000 and 19 500 U/kg, respectively.

Animal husbandry. All husbandry practices and euthanasia were done with full consideration of animal welfare. Poults were allocated at random to 20 pens (50 turkeys per pen, 250 birds per treatment) with straw as bedding material. All the pens had the same stocking density of approximately 50 kg LBW/m^2 of usable floor space. A pen was considered as a replicate experimental unit.

Brooder rings for poults (till 10 days of age) and additional heat sources (till 28 days of age) were installed in the pens. Heating was provided by a central heating system and electric heaters (red light). The brooder unit's temperature was set at 35°C and was then altered as needed to suit bird comfort. Room temperature was set at 28°C on the day of placement, and was subsequently reduced by 2°C per week. The temperature and humidity were recorded on a daily basis at 8 AM and 3 PM. The lighting program in the room was as follows: 23 h light at about 100 lux till 3rd day of age and 14 h light at 5-6 lx from 4th day till the end of the experiment. Relative humidity was about 65 to 70%. Air changes were 0.4-0.5 m^3/h/kg of BW from 2 to 7 weeks of age and 0.7-0.8 m^3/h/kg of BW at eight weeks of age.

Tab. 1. Composition and calculated nutrient content (g/kg) of the basal diets fed to turkeys from 1st to 56th days of age

Ingredient	Feeding period	
	Starter 1-28 days	Grower 29-56 days
Wheat	366.23	397.29
Soybean meal, 47% CP	341.83	266.82
Barley	100.00	100.00
Potato protein	50.00	50.00
Rapeseed meal, 34% CP	50.00	50.00
Sunflower meal, 36% CP	–	50.00
Soya oil, 98%	21.82	25.52
Fat animal, 99%	15.00	15.00
Monocalcium phosphate	29.84	24.84
Limestone	13.15	10.06
Salt	3.32	3.32
DL methionine	1.58	1.35
L Lysine HCL	2.03	0.80
L Threonine	0.20	–
Vitamin-mineral premix*	0.50	0.50
Nutrients (calculated)		
ME, MJ/kg	11.50	11.65
Crude protein	275.00	260.00
Lysine	17.50	15.00
Methionine + cystine	11.11	10.63
Threonine	11.30	10.42
Ca	12.50	10.50
P available	7.50	6.50
Na	1.51	1.52
Cl	2.15	2.70

Explanations: * supplied the following per kilogram of feed starter/grower: 15 000/13 000 IU vit A, 4 000/3 000 IU vit D_3, 40/35 mg vit E, 2.5/2 mg vit K_3, 2.5/2 mg vit B_1, 10/8 mg vit B_2, 5/3.5 mg vit B_6, 70/65 mg niacin, 20/18 mg pantothenic acid, 2/1.5 mg folic acid, 0.3/0.2 mg biotin, 600/400 mg choline, 120/100 mg Mn, 90/80 mg Zn, 60/50 mg Fe, 10/8 mg Cu, 1/0.8 J, 0.3/0.3 mg Se

Procedures. The ingredients of mixtures were mixed using a horizontal ribbon blade mixer. This mixer has a capacity of 1,000 kg and a batch was mixed for a period of 3 minutes. The mixture was then moved into a conditioner where steam was added at a pressure of 1.5 bar and it was heated at a set temperature of 65°C for 10-15 seconds. The temperature was monitored at the conditioner outlet and controlled by a Data-

stor computerized press controller (with a maximum variation from the set temperature of ± 1°C). After the diets were produced as pellets, they passed into a cooler. The diets were then transferred to a second mixer where enzyme blend was sprayed on the pellets.

The group feed intake (g) and body weights (g) were recorded on 28th and 56th day of age. On the 1st day of age, the attending veterinary surgeon administered the Nobilis TRT vaccine. Visual health inspection of all birds within the study was performed daily and the weights of culled birds and the reasons they were removed were recorded. All mortality turkeys were weighed soon after death and recorded so that their weights could be included in the calculation of feed conversion.

The entire experiment lasted 8 weeks, after which the birds were weighed. Eight turkeys representing the average body weight of each group were euthanized. After laparotomy, the small intestinal and caecal contents were removed and the caecal contents were weighed. The caecal pH was measured using a microelectrode and pH/ION meter (model 301, Hanna Instruments). Samples of fresh digesta were used for measuring caecal microbiota, the remainder was transferred to microfuge tubes and stored at –40°C to measure digesta viscosity and volatile fatty acid (VFA) content. Empty intestine and caeca were flushed clean with ice-cold saline, blotted and weighed.

The samples for caecal microbial count were collected in sterile conditions and serials of decimal dilutions were prepared in physiological liquid. Inoculations were preformed using the standard plate method and cultivating media purchased from Merck. Caecal microbiota included residual content of lactic acid bacteria (MRS–Agar medium, incubation at 37°C for 72 h in anaerobic conditions), *Enterobacteriaceae* and *Escherichia coli* (Chromocult® Coliform Agar, at 37°C for 24 h) and aerobic spore-forming bacteria (Standard I Nutrient Agar medium, at 30°C for 72 h) and *Clostridium* (Agar TSN medium, at 37°C for 48 h). Before inoculation, digesta samples for aerobic spore-forming bacteria and *Clostridium* cultivation measurements, were pasteurized at 80°C for 10 min. to eliminate vegetative bacteria.

Viscosity measurements of intestinal and caecal digesta were determined using a Brookfield cano-plate Viscometer Model LVDV-II + CP40 (Brookfield Engineering Laboratories Inc. Stoughton, MA). Samples of ileal digesta (about 2 g) were expressed from Meckel's diverticulum to ileocaecal junction. Then were centrifuged (13,000 rpm, 15 min. at 20°C) and the supernatant was collected. The viscosity of the supernatants was determined at 25°C and with shear rates of 300--600 sek^{-1}. The reading was taken after one minute.

The caecal digesta samples were also measured for volatile fatty acid (VFA) concentration by gas chromatography (Shimadzu GC-14A with a glass column 2.5 m × 2.6 mm, containing 10% SP-1200/1% H_3PO_4 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 deionized water and centrifuged at 10,000 rpm for 5 min. The supernatants were decanted for injection in the gas chromatograph. Caecal VFA pool size was calculated as the product of VFA concentration in digesta and caecal digesta mass.

Statistics. All data were analyzed statistically by a one--factor analysis using the general linear models procedure for ANOVA and the Duncan's multiple range test. Replicate means served as the experimental units for statistical analysis. The treatment effects were considered to be significant at $P \leq 0.05$.

Results and discussion

Animal growth and feed conversion. The effects of blend of enzymes (β-xylanase and β-glucanase), given in different doses on the performance of turkeys are presented in tab. 2.

There were no significant differences in poults starting weights at one day of age (60-61 g). Cumulative viability averaged 98% for the entire experiment and was not significantly influenced by enzyme supplementation (data not shown).

Xylanase and glucanase blend addition not affect on the feed intake (FI) within 28 days of age. A statistically significant increase (5.0%; $p \leq 0.05$) in feed intake, in comparison with the lowest level of enzyme blend, was recorded in K2 group with the medium dose of enzymes. At the end of the experimental period however, the addition of xylanase and glucanase blend decreased feed intake numerically but the effect was statistically insignificant.

On 28 day of age, the body weights of turkeys fed diets with a medium level of enzymes (K2) were by 3.5% ($p \leq 0.05$) higher than in control and K1 group, whereas no significant differences in body weight was noted between turkeys of particular groups at 8 weeks of age.

The feed conversion ratio (FCR) revealed the positive response of turkeys to the experimental factor. Xylanase and glucanase addition for the first four weeks of rearing resulted in reduced FCR by 1.2-2.5%,

Tab. 2. Effects of diets containing different levels of enzyme* supplementation on feed intake (FI), feed conversion ratio (FCR) and live body weight (LBW) of turkeys raised from 1st to 56th days of age

Days	Control	K1	K2	K3	SEM
Feed intake [g**]					
1-28	1401^{ab}	1366^{a}	1434^{b}	1395^{ab}	10
1-56	6486	6423	6396	6242	45
Live body weight [g**]					
28	883^{a}	883^{a}	914^{b}	897^{ab}	3
56	3519	3471	3570	3510	7
FCR [g/kg**]					
1-28	1586	1546	1567	1554	7
1-56	1841^{bc}	1851^{b}	1792^{ac}	1778^{a}	11

Explanations: a-c means with different superscripts within the some line differ significantly ($P \leq 0.05$). There were no significant differences in poults weights on 1st of age (60-61 g); * contains 210 000 U/g of endo-1,4-β-xylanase activity; 10 000 U/g of endo-1,3(4)-β-glucanase activity and 12 000 U/g of endo-1,4-β--glucanase activity. The dosage used was 50, 100 and 150 mg/kg of feed; ** values represent means of 5 replicates. Data from 4 treatments (1 control-without enzyme, 3 with enzyme).

but these differences were statistically insignificant. The medium and highest level of enzyme blend significantly improved cumulative FCR within 56 days of age, in comparison with the control group and also with the lowest addition of the enzymatic supplement. A statistically significant decrease (3.4%; $p \leq 0.05$) in feed conversion, in comparison with the control group, was recorded in group K3 with the highest dose of enzymes.

Physiological parameters of the small intestine and caeca. Table 3 presents the physiological parameters of selected segments of the gastrointestinal tract of turkeys fed diets for eight weeks containing different levels of carbohydrase enzymes.

Xylanase and glucanase blend reduced intestinal and caecal viscosity in turkeys, but significant differences ($p \leq 0.05$) were revealed only in turkeys with the highest addition of the enzymatic supplement (K3). The highest dose (150 mg/kg) of enzyme preparation decreased ileal viscosity by 9% (2.42 vs. 2.66 mPa.s) and caecal viscosity by 20% (9.12 vs. 11.36 mPa.s) in comparison with control. Compared to the control group, the turkeys of experimental groups (enzyme supplementation) had also lower small intestinal tissue weight, especially in the group K3 with the highest addition of the enzymatic supplement (10.6 vs. 13.4 g/kg BW, $p \leq 0.05$). A visible (but statistically insignificant) decrease in pH of intestinal content was observed in turkeys fed diets containing the enzyme preparation. Supplementation of diets with β-xylanase and β-glucanase blend in a small degree influenced on mass of caecal wall and pH value of the caecal digesta.

Diet supplementation with the blend of β-xylanase and β-glucanase caused a visible, but not statistically confirmed, growth tendency in total volatile fatty acid (FVA) in the caecal digesta of turkeys. At the same time, the proportions of major fatty acids also changed (compared to the control group). The production of acetic acid increased and the production of propionic acid decreased. The highest total production of short-chain fatty acids in caecal digesta (VFA pool) was observed in the group of turkeys fed the diet with the highest supplementation of enzyme preparation (K3).

Microbial populations of the caeca. Table 4 presents the effect of enzyme addition on the content of caecal microbiota in turkeys. Xylanase and β-glucanase addition did not affect the number of lactic acid bacteria in caecal digesta. The counts of *Enterobacteriaceae* and *Escherichia coli* also did not significantly differ among the examined groups. Similarly, no influence of enzyme supplementation, irrespective of dose, on the counts of *Clostridium perfringens* was observed. At the same time, counts of aerobic spore forming decreased, especially in the group with the medium and highest addition of the enzymatic supplement (K2 and K3, $P \leq 0.05$).

These investigations were conducted to evaluate the use of different levels of NSP degrading blend of en-

Tab. 3. The effect of enzyme addition on intestinal parameters and on concentration of volatile fatty acids (VFA) in the caeca digesta of turkeys

Intestinal parameters	Control	K1	K2	K3	SEM
Viscosity of digesta (mPa.s)					
Ileal	2.66^{b}	2.58^{ab}	2.54^{ab}	2.42^{a}	0.03
Caecum	11.36^{b}	10.50^{b}	10.52^{b}	9.12^{a}	0.23
pH of digesta					
Ileal	6.04	5.78	5.61	5.62	0.08
Caecal	5.47	5.69	5.61	5.74	0.05
Intestinal digesta (g/kg BW)					
Ileal	ND	ND	ND	ND	
Caecal	3.603	3.971	3.799	4.171	0.22
Intestinal wall (g/kg BW)					
Ileal	13.43^{b}	11.63^{ab}	11.68^{ab}	10.56^{a}	0.17
Caecal	3.585	3.449	3.495	3.670	0.07
VFA concentration (µmol/kg BW)					
acetate – C_2	178.33	203.86	215.01	210.44	13.37
propionate – C_3	106.47	89.17	80.58	83.90	6.92
isobutyrate – C_{4i}	2.50	4.02	3.23	4.80	0.46
butyrate – C_4	64.58	68.73	75.19	79.28	4.51
isovalerate – C_{5i}	3.18	4.27	3.72	4.67	0.40
valerate – C_5	8.39	9.17	8.81	9.66	0.67
Total VFA	363.46	379.22	386.06	392.74	24.21
Profile C_2:C_3:C_4, %	49^{a}:29^{b}:18	54^{ab}:23^{ab}:18	56^{b}:21^{a}:19	53^{ab}:22^{ab}:20	–

Explanations: a-b means with different superscripts within the some line differ significantly ($P \leq 0.05$); ND – not determined

Tab. 4. The effect of enzyme addition on the content of caecal microbiota in turkeys (log_{10}cfu/g)

Microflora	Control	K1	K2	K3
Lactic acid bacteria	6.36	6.46	6.39	6.44
Enterobacteriaceae	4.43	4.85	4.98	4.90
Escherichia coli	4.09	4.35	4.47	4.73
Aerobic spore former	2.71^{b}	2.36^{ab}	2.10^{a}	2.27^{a}
Clostridium perfringens	2.34^{ab}	2.62^{b}	2.03^{a}	2.10^{a}

Explanations: a-b means with different superscripts within the some line differ significantly ($P \leq 0.05$)

zymes (β-xylanase and β-glucanase) in wheat-based diets for growing turkeys. The commercial enzyme product used in this experiment, contained predominantly endoxylanase (210 000 U/g of product) along with 1,3- and 1,4-β-endoglucanase (10 000 U/g and 120 000 U/g, respectively). A blended preparation of enzymes was chosen because enzyme blends usually improve the nutritional value of wheat-based diets for monogastric animals more effectively than single enzyme preparations (19).

In the presented study, enzyme supplementation significantly improved cumulative FCR within 56 days of age in turkeys fed wheat-based diets. This is in general agreement with other reports (5, 11). The results of research show that these positive responses were attributed to the enzymes ability to alleviate the adverse effects of excess dietary NSP (5, 6, 14). In an experiment by Santos et al. (21) endoxylanase with β-glucanase supplementation significantly increased dietary energy (AMEn) and the protein utilization, body weight, feed consumption and improved FCR by about 4% in turkeys fed wheat-based diets. Murphy et al. (18) reported that the various xylanases added to a wheat-based diets increased the growth performance of broilers, but the effect was not significant for all the xylanases-treated diets. In an experiment by Wang et al. (27), enzyme supplementation linearly increased ($p < 0.01$) daily gain and FCR of broilers with increasing levels of enzyme supplementation.

The disruption of cell wall integrity and release of encapsulated nutrients most likely contributed to the overall improvements with carbohydrase enzyme supplementation observed in the current turkey study. In this regard, NSP might act as a physical barrier preventing or slowing access of endogenous enzymes to starch granules. The microscopy study by Bedford and Autio (4) demonstrated that there was indeed a considerable amount of starch surrounded by intact cell walls in the intestinal digesta of broilers fed wheat based diets, which was largely removed on addition of an NSP degrading carbohydrase.

In the current study, supplementation of diets with carbohydrases in high amounts (150 mg/kg) decreased intestinal viscosity of digesta and mass of intestinal wall. A distinctly lower pH of intestinal digesta, although not statistically certified, was also observed.

Carbohydrase enzymes are capable of partially degrading soluble NSP (i.e. soluble arabinoxylans and/or β-glucans) into smaller molecular weight polymers and thus decreasing digesta viscosity. The reduction in viscosity has been suggested as the main reason for improved growth performance and nutrient utilization in the enzyme supplemented wheat/barley based diets (22). It has to be emphasized, however, that in the current experiment a relatively low digesta viscosity value was found for the control birds (2.66 mPas). Low viscosity values were reported by Meng et al. (17) in study utilizing wheat based diets. Therefore, the extent to which a further reduction in digesta viscosity contributed to the responses from dietary carbohydrase addition cannot be determined from the current study. It is noteworthy that such responses from enzyme supplementation generally ocurred for wheat/barley-based diets of relatively low viscosity, suggesting that other factors may be of importance in situations when digesta viscosity is low.

The adverse effects of microbial fermentation in the small intestine include deconjugation of bile salts reducing fat digestion (15), competition between the host and the microbiota for nutrients (14), atrophy of the intestinal villi, and enlargement of digestive organs (26). In experiment by Wu et al. (29) the addition of xylanase to wheat-based diets improved performance with reduced digesta viscosity, but had no effects on the relative weight of the small intestine. In other studies (27, 28) the addition of xylanase or xylanase with β-glucanase reduced the relative weight of the small intestine. The explanation for the relatively heavier intestinal weights of birds fed the non-supplemented wheat-based diet probably lies in the increased pathogenic microbial activity that stimulate intestinal tissue growth (28).

The beneficial effects of supplementary carbohydrases include improved digestibility of nutrients, reduced small intestinal fermentation and increased caecal fermentation (6). In the present study, supplementation of a wheat/barley-based diet with enzyme preparation caused a growth tendency in total VFA, mainly acetic acid in the caecal digesta of turkeys. This is in general agreement with the results of Wang et al. (27). The increase in C_2 acid, accompanied by a decrease in C_3 acid, may suggest that in the birds fed diets supplemented with an enzyme preparation, cellulose played a more important role among the non-starch polysaccharides in bacterial fermentation in the caecum. VFA are responsible for normalizing gut cell proliferation (9). In fact, the most likely source of the VFAs is through the action of the caecal bacteria which are capable of utilizing xylose and xylo-oligomers as a fermentation source. At all ages, acetic acid is the most predominant VFA followed by propionic and butyric acid (24). Choct et al. (6) and Wang et al. (27) reported that xylanase or xylanase with β-glucanase supplementation significantly increased caecal fermentation in chickens fed wheat diets, but did not alter the ratios of these VFA. The proposed mechanism by which glucanases increase caecal fermentation is that more low molecular weight carbohydrates enter the caeca, as a result of reduced digesta viscosity (3). In an experiment by Józefiak et al. (13) the increasing VFA concentration was more pronounced: almost two times in broiler fed barley or oat-diets supplemented with higher content of enzymes, xylanase 300 U/kg and protease 800 U/kg. In other studies, the different contents of enzyme preparations added to rye diets did not increase the VFA concentration in caecal digesta (16).

The influence of increased viscosity in stimulating the growth of anaerobic microbiota is well-documented. Langhout et al. (14) reported that excess dietary NSP increased digesta viscosity, which caused changes in gut microbiota and decreased nutrient digestion and absorption. As reported by Choct et al. (6), the addition of xylanase to wheat-based diets reduced the microbial activity of ileal digesta as indicated by reduced concentrations of VFA. The increased microbial activity in the caeca is a likely result of poorly absorbed products of enzymatic degradation entering the caeca, where they stimulate bacterial fermentation (3).

In the present study, enzyme supplementation did not affect the number of lactic acid bacteria, *Enterobacteriaceae*, *Escherichia coli* and *Clostridium perfringens*, but decreased counts of aerobic spore former count in the caeca of turkeys. This may be a part of an overall change in total microbiota profile as noted by Apajalahti and Bedford (2) and further supports the hypothesis that carbohydrases may exert part of their response from changes in relative microbiota populations. On the other hand, Sinlae and Choct (23) reported that the addition of xylanase to a wheat-based diet reduced the number of undesirable organisms such as *Clostridium perfringens* in caecal contents. *Clostridium perfringens* infection of meat type poultry may cause impairment of production performance and subclinical or clinical disease associated with necrotic enteritis. In an experiment by Murphy et al. (18) xylanase addition decreased *Lactobacillus* number and coliform counts in the caecum. Vahjen et al. (25) and Hübener et al. (10) reported that the less viscous intestinal environment caused by the xylanase slowed proliferation of gram positive cocci and enterobacteria in intestinal samples of growing broiler chicks, but distribution of *Lactobacillus spp.* colony forms was unaffected by xylanase treatment. Salih et al. (20) reported that the addition of α-glucanase to a barley-based diet tended to have lower total bacterial counts in caecal contents.

In conclusion, the presented study show that supplementation of practical wheat/barley-based diets with a blend of exogenous xylanase and β-glucanase had a positive effect on the functions of the small intestine and caecum of turkey, reflected by noticeable positive changes in physiological indicators and performance of birds. The best results were achieved with the highest addition of enzyme preparation to diet.

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