

Efficacy of free-choice feeding of ground wheat or whole grain wheat and protein concentrate to turkeys*

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The aim of this study was to determine body weight gains, feed intake and feed consumption patterns in turkeys, when offered a choice of various feed ingredients (protein-fat-mineral-vitamin concentrate pellets, ground-pelleted wheat and whole grain wheat). The experiment started on 264 male Hybrid Converter turkeys aged 4 weeks, divided into four experimental groups with six replicates per treatment and 11 birds per replicate. Group I birds were fed a complete pelleted diet formulated to meet the nutrient requirements of turkeys at 5-8 and 9-12 weeks of age. Turkeys in the other three groups had free access (FCF) to protein concentrate pellets (supplemented with fat, minerals and vitamins), ground-pelleted wheat (group II), ground-pelleted wheat and whole grain wheat (group III), and whole grain wheat (group IV).

Throughout the experiment, average feed intake in the FCF groups accounted for 91.8 -93.0% of feed intake in group I. In the control group receiving the complete feed the intake of the components making up the protein concentrate used in the diets of groups II-IV was calculated as 43.2% of total feed intake, whereas the intake of protein concentrate in groups II, III and IV constituted 48.4, 46.2 and 65.6% of total feed intake, respectively. In comparison with group I, daily total protein intake was 6.7 and 5.4% lower in groups II and III, and 26.8% higher in group IV in the first feeding period; the differences between groups were less pronounced in the second feeding period. After 4 and 8 weeks of feeding, body weights (BW) of turkeys in the FCF groups were significantly lower than in group I ($P=0.001$ in both periods). In both feeding periods, total protein intake per kg weight gain in the experimental groups could be arranged in the following order: $IV>III>II>I$ ($P=0.001$). FCF had no significant effect on excreta dry matter (DM) content and footpad dermatitis (FPD) incidence in 12-week-old turkeys.

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FCF resulted in poorer growth performance of turkeys due to inadequate total protein intake, which was too low when the birds were given a free choice between protein concentrate and ground-pelleted wheat, and too high when protein concentrate and whole grain wheat were fed in the free choice system. Considerable disproportions in the consumption of protein concentrate and wheat, in particular whole grain wheat, suggest that turkeys aged 5-8 weeks either need a longer time to fully adapt to FCF or are not able to adapt to FCF at all.

KEY WORDS: free-choice feeding / growth performance / turkeys / whole wheat grain

The feed preferences of birds and their responses to different physical forms of feed have been tested under free-choice feeding (FCF) systems, with special emphasis on factors in the feed which determine its intake [Pousga *et al.* 2005]. FCF has been believed to be of particular importance to small poultry producers in developing countries, because it can substantially reduce the cost of feed [Henuk and Dingle 2002]. In large poultry farms a practical limitation to the application of FCF is that it requires extra equipment, as whole wheat and a balancer or complete diet have to be provided *ad libitum* in separate feeders.

In recent years we have witnessed an increasing interest in feed preferences of birds also in intensive poultry farming, due to the growing popularity of whole grain. Whole grain is incorporated into poultry diets to stimulate digestive tract development and improve the health status of birds without the use of antibiotics [Biggs and Parsons 2009].

Rose *et al.* [1995] demonstrated that FCF birds usually select a diet that ensures rapid growth, but occasionally they will eat too much balancer and not enough whole wheat, resulting in higher feed costs. In some experiments [Amerah and Ravindran 2008] lower BW of broiler chickens was observed when whole wheat was offered with a balancer pellet or mash diet. In contrast, Gabriel *et al.* [2003] found no effect of whole wheat on the performance of broilers offered free choice plus a pelleted complementary diet. In another study [Gabriel *et al.* 2008], a significant improvement was observed in the BW of broiler chickens, with no effect on feed intake and feed efficiency, when whole wheat was given in FCF, with complementary feed in the mash form.

One of the few experiments on turkeys [Classen and Bennett 1996] revealed that dilution of a diet with whole wheat starting from 5% (in the starter diet) to 35% (in the finisher diet) could be applied in turkey nutrition without affecting growth performance. The results of a subsequent study by the same authors [Bennett and Classen 2003] were much less promising, suggesting that reports of successful dilution of poultry rations are more likely due to the use of formulation with excess nutrient levels in the undiluted diets rather than a specific benefit to feeding whole grain.

The results of our earlier study [Jankowski *et al.* 2012a] indicated that moderate dilution of standard turkey diets with whole wheat (18% on average during feeding between 4 and 18 weeks of age) had no effect on the final body weights (FBW) of birds, but improved feed utilization due to desirable changes in gastrointestinal (GIT) microflora and better function of the lower GIT [Zdunczyk *et al.* 2013, Jankowski *et*

al. 2014]. In another experiment [Jankowski *et al.* 2013b], lower inclusion rates of whole wheat, below 25% and 30% of the diet, did not cause significant changes in GIT function or the FBW of turkeys; however, high dietary levels of grain contributed to a decrease in the FBW of birds and a deterioration in feed efficiency. The inclusion of whole wheat in the diet increased the proportion of coarse particles in the digesta leaving the gizzard, which did not reduce nitrogen retention or the apparent digestibility of dry matter, crude fat and crude fiber assessed for the whole gastrointestinal tract [Jankowski *et al.* 2013a].

One of the first experiments on turkeys under FCF indicated that the birds voluntarily consumed half of their feed intake as whole barley [Cowan and Michie 1977]. However, a similar study revealed higher efficiency in terms of daily gains and FBW in turkey poults fed a starter diet and whole wheat in the FCF system [Erener *et al.* 2006]. Forbes and Covasa [1995] speculated that while birds self-select the grain and protein concentrate, some factors may interfere with their choices. Feed form and shape are important, with birds preferring to eat larger particles as they grow older.

Since the above mentioned research findings are scarce and inconclusive, we launched a study to determine body weight gains, feed intake and feed consumption patterns in turkeys older than 4 weeks, when offered a choice of various feed ingredients (protein-fat-mineral-vitamin concentrate pellets, ground-pelleted wheat and whole grain wheat).

Material and methods

The experiment was conducted at the experimental poultry farm of the Department of Poultry Science, University of Warmia and Mazury in Olsztyn (Poland). The animal protocol used in this study was approved by the Local Animal Care and Use Committee (resolution No. 21/2010/N). The experiment started on 264 male heavy-type Hybrid Converter turkeys aged 4 weeks, with similar BW, divided into four experimental groups with six replicates per treatment and 11 birds per replicate. Until 4 weeks of age all turkeys were fed an identical commercial starter diet. At the beginning of the experiment the average BW of birds was similar in all groups (0.97 kg) and lower than reported for male Hybrid Converter turkeys aged 4 weeks. From 5 to 12 weeks of age, the birds were kept in pens on litter in a building with a controlled environment. The temperature and lighting program were consistent with the recommendations for Hybrid Turkeys [2012]. The birds had free access to feed and water.

Control group (I) birds were fed a complete pelleted diet formulated to meet the nutrient requirements of turkeys at 5-8 and 9-12 weeks of age. Turkeys in the other three groups (group II with ground-pelleted wheat, group III with ground-pelleted wheat and whole grain wheat, and group IV with whole grain wheat) had free access to protein-fat-mineral-vitamin concentrate pellets with a 38 and 37% total protein content and a 2.670 and 2.740 kcal/kg metabolizable energy content in the first and second feeding period, respectively.

Table 1. Components and nutrient contents of complete diets and concentrate fed to turkeys from 5 to 8 and from 9 to 12 weeks of age

Item	Complete diet		Concentrate		Wheat grain
	5-8 weeks	9-12 weeks	5-8 weeks	9-12 weeks	
Component (g/kg as-fed basis)					
Wheat (12.0% CP)	500.0	600.0	-	-	
Soybean meal (46% CP)	388.1	300.0	776.0	750.0	
Rapeseed (20.5% CP)	40.0	30.0	80.0	75.0	
Soybean oil	27.8	28.3	55.6	70.7	
Limestone	15.7	14.7	31.4	36.7	
Monocalcium phosphate	16.4	14.3	32.8	35.8	
Choline chloride	0.7	0.7	1.4	1.7	
Salt	2.8	2.9	5.8	2.0	
DL-Methionine ¹	1.8	2.0	3.5	5.0	
L-Lysine HCL ²	3.8	3.3	7.6	8.2	
L-Threonine ²	0.4	1.3	0.9	3.4	
Vitamin- mineral premix ³	2.5	2.5	5.0	6.2	
Calculated analysis ⁴					
AME (kcal/kg)	2 870	2 938	2 670	2 740	3 060
CP (g/kg)	250.0	220.0	380.0	370.0	120.0
Lys (g/kg)	15.5	13.0	27.6	27.3	3.4
Met (g/kg)	5.2	5.1	8.5	9.8	1.9
Met + Cys (g/kg)	9.5	9.0	14.3	15.4	4.7
Thr (g/kg)	9.2	8.8	15.0	17.0	3.4
Trp (g/kg)	3.2	2.8	5.0	4.8	1.4
Arg (g/kg)	15.8	13.4	25.8	24.9	5.7
Ca (g/kg)	11.0	10.0	21.5	24.2	0.5
Available P (g/kg)	5.5	5.0	9.1	9.7	1.3
Na (g/kg)	1.3	1.3	2.6	3.2	0.1

¹ MetAMINO®, Evonik Degussa GmbH, Essen, Germany, 99% of methionine.

² Ajinomoto Eurolysine S.A.S, Amiens, France, 78% of lysine, 98.5% of threonine.

³ Provided the following per kilogram of diet in the successive (5-8, 9-12, and 13-18 weeks) feeding periods: retinol 3.38, 2.88, and 2.52 mg, cholecalciferol 0.12, 0.10, and 0.09 mg, α -tocopheryl acetate 94, 80, and 70 mg, vitamin K₃ 5.6, 4.8, and 4.2 mg, thiamine 4.7, 4.0, and 3.5 mg, riboflavin 7.5, 6.4, and 5.6 mg, pyridoxine 5.6, 4.8, and 4.2 mg, cobalamin 0.028, 0.024, and 0.021 mg, biotin 0.28, 0.24, and 0.21 mg, pantothenic acid 24, 20, and 18 mg, nicotinic acid 75, 64, and 56 mg, folic acid 2.8, 2.4, and 2.1 mg, Fe 60, 56, 48, and 42 mg, Mn 112, 96, and 84 mg, Zn 103, 88, and 77 mg, Cu 19, 16, and 14 mg, I 2.8, 2.4, and 2.1 mg, Se 0.28, 0.24, and 0.21 mg, choline chloride 376, 320, and 280 mg, respectively.

⁴ Calculated from the analyses of feed formulation provided by the manufacturer.

The composition and nutritional value of experimental diets are shown in Table 1. Wheat grain was ground with a hammer mill (Jesma Co., Sprout Matador, Denmark) at 3,000 rpm and a screen diameter of 4 mm. The complete diet and ground wheat were pelleted using the same pelletizer machine (Jesma Co., Sprout Matador, Denmark) at approximately 60°C. In weeks 5 to 8 the diameter of diet and concentrate pellets was 3 mm, while the diameter and length of wheat pellets were 4 mm and approximately 2 to 3 mm, respectively. In weeks 9 to 12 the diameter of all feed pellets was 4 mm. Wheat grain from the same batch was used in all dietary treatments and its chemical

composition was estimated based on crude protein (CP) content (120.0 g/kg, as-fed basis) and Polish feedstuff analysis tables: AME, 3,060 kcal/kg; ether extract, 20 g/kg; crude fiber, 25 g/kg; Lys, 3.4 g/kg; Met + Cys, 4.7 g/kg [Smulikowska and Rutkowski 2005]. Diets did not contain any other feed additives.

Feed intake and mortality rates were recorded throughout the experiment (the weights of dead birds were used to adjust average daily gain) and the BW of birds aged 8 and 12 weeks were determined. Body weight gains, ME and CP conversion ratios were calculated for each feeding period. In the last week of the experiment five samples of fresh feces were collected from each replicate. The samples were pooled and excreta DM content was determined. At the termination of the experiment, all birds were weighed and FPD scores were determined according to the method described by Hocking et al. [2008] on a five-point scale (0-4 points): score 0 – the skin of the footpad feels soft to the touch and no swelling or necrosis is evident, score 4 – more than half of the footpad is covered by necrotic cells.

The data were processed statistically by one-way ANOVA. Each replicate pen (n=6) was considered as an experimental unit for all performance parameters. The model assumptions of normality and homogeneity of variance were examined by the Shapiro-Wilk and Levene tests, respectively. The percentage data of excreta DM content were transformed to arcsine of the square root before the statistical analysis to obtain normal distribution of residuals and homogeneity of treatment variances. The Newman-Keuls test was used to determine the statistical significance of differences between the group means. All data were expressed as mean values with pooled SE. These computations were performed using the STATISTICA software system ver. 10PL (StatSoft Inc., 2011).

Results and discussion

In the first feeding period (weeks 5-8), feed intake was lower by 1.7-3% in the FCF groups (II, III and IV) than in group I, but the differences relative to group I were insignificant (Tab. 2). In the first feeding period, protein concentrate accounted for 46.5, 47.6 and 81.1% of total feed intake in groups II, III and IV, respectively; in group I, the components of protein concentrate (including oil, mineral and vitamin supplements) made up 50% of the ration. In the second feeding period, protein concentrate accounted for 49.2, 45.6 and 58.7% of total feed intake in groups II, III and IV, respectively; in group I the ingredients of protein concentrate made up 40% of the ration. Throughout the experiment protein concentrate accounted for 43.2, 48.4, 46.2 and 65.6% of total feed intake in groups I, II, III and IV, respectively (the value in group I was adjusted). Over the entire experimental period, average feed intake in the FCF groups accounted for 91.8-93.0% of feed intake in group I fed a complete pelleted diet, and the differences between group I and groups II, III and IV were significant ($P=0.032$).

Table 2. Daily feed intake (g/bird)¹

Item	Type of feed				Total	
	complete diet	concentrate	ground wheat	whole grain wheat	g	%
5-8 weeks						
group ²						
I	202.9	-	-	-	202.9	100.0
II	-	91.4	105.2	-	196.6	98.3
III	-	93.8	100.1	3.0	196.9	97.0
IV	-	157.8	-	36.7	194.5	95.9
SEM					2.65	
P value					0.732	
9-12 weeks						
group ²						
I	432.8	-	-	-	432.8 ^a	100.0
II	-	196.0	202.0	-	398.0 ^b	92.0
III	-	178.2	200.9	11.9	391.0 ^b	90.3
IV	-	234.3	-	164.9	399.2 ^b	92.2
SEM					5.18	
P value					0.010	
5-12 weeks						
group ²						
I	321.4	-	-	-	321.4 ^a	100.0
II	-	145.1	154.7	-	299.8 ^b	93.3
III	-	136.5	151.1	7.6	295.2 ^b	91.8
IV	-	197.9	-	104.0	301.9 ^b	93.9
SEM					3.53	
P value					0.032	

¹Data represent mean values of 6 replications per treatment. SEM – standard error of the mean (SD divided by the square root of replication number, n=24).

²Group I – complete pelleted diet; other groups (II – ground-pelleted wheat, III – ground-pelleted wheat and whole grain wheat, IV – whole grain wheat) had free access to concentrate pellets.

^{ab}Within the same column means bearing different superscripts differ significantly at P<0.05.

Considerable differences were observed among groups in the consumption of ground-pelleted wheat and whole grain wheat. In group III whole grain intake accounted for only around 3 and 6% of ground wheat intake in the first and second feeding periods, respectively. Whole grain intake in group IV accounted for 35 and 82% of ground wheat intake in group II in the first and second feeding periods, respectively. Differences in the intake of ground-pelleted wheat and whole grain wheat affected protein concentrate intake and daily total protein intake, particularly in the first feeding period. An analysis of feed consumption patterns and the protein content of feeds shows that in the first feeding period the daily total protein intake was 6% lower in groups II and III, and 27% higher in group IV when compared with group I fed a complete diet. In the second period the daily total protein intake was similar in groups I, II and III, and 11% higher in group IV.

Table 3. Body weights and body weight gains of turkeys¹

Item	Group ²				SEM	P value
	I	II	III	IV		
Body weight (kg)						
5 weeks	0.97	0.97	0.97	0.97	0.008	0.993
8 weeks	4.56 ^a	3.76 ^c	3.75 ^c	4.04 ^b	0.077	0.001
12 weeks	10.48 ^a	9.27 ^b	9.17 ^b	9.44 ^b	0.126	0.001
Body weight gain (kg)						
5-8 weeks	3.593 ^a	2.786 ^c	2.781 ^c	3.064 ^b	0.076	0.001
9-12 weeks	5.918 ^a	5.515 ^b	5.418 ^b	5.377 ^b	0.068	0.008
5-12 weeks	9.511 ^a	8.301 ^b	8.199 ^b	8.441 ^b	0.124	0.001

¹Data represent mean values of 6 replications per treatment. SEM – standard error of the mean (SD divided by the square root of replication number, n=24).

²Group I – complete pelleted diet; other groups (II – ground-pelleted wheat, III – ground-pelleted wheat and whole grain wheat, IV – whole grain wheat) had free access to concentrate pellets.

^{ab}Within the row means with no common superscripts differ significantly bearing at P<0.05.

After 4 and 8 weeks of feeding the BW of turkeys (Tab. 3) in the FCF groups were significantly lower than in group I fed a conventional diet (P=0.001 in both periods). At the end of the first feeding period, the BW of turkeys from groups II and III were significantly (P=0.001) lower than in group IV. At the end of the second feeding period the BW of turkeys in the FCF groups were comparable. Similar differences were observed in the body weight gains of turkeys in both feeding periods and over the entire experiment.

Significant differences were recorded in ME and CP conversion between the FCF groups and group I (Tab. 4). In the first feeding period turkeys from groups II, III and IV were significantly (P=0.001) less efficient in converting feed energy to weight gain than group I turkeys. After 4 weeks of feeding the energy consumption levels

Table 4. Average metabolizable energy and crude protein conversion in turkeys aged 5-12 weeks¹

Item	Group ²				SEM	P value
	I	II	III	IV		
Metabolizable energy (Mcal/kg BW)						
5-8 weeks	4.72 ^c	5.94 ^a	5.97 ^a	5.11 ^b	0.126	0.001
9-12 weeks	6.88	6.91	6.96	6.83	0.051	0.871
5-12 weeks	6.04 ^b	6.56 ^a	6.58 ^a	6.19 ^b	0.065	0.001
Crude protein (g/kg BW)						
5-8 weeks	410.7 ^c	493.3 ^b	502.4 ^b	609.0 ^a	15.25	0.001
9-12 weeks	514.9 ^c	576.7 ^b	555.1 ^b	632.0 ^a	9.86	0.001
5-12 weeks	474.6 ^c	546.9 ^b	535.3 ^b	623.4 ^a	11.41	0.001

¹Data represent mean values of 6 replications per treatment. SEM – standard error of the mean (SD divided by the square root of replication number, n=24).

²Group I – complete pelleted diet; other groups (II – ground-pelleted wheat, III – ground-pelleted wheat and whole grain wheat, IV – whole grain wheat) had free access to concentrate pellets.

^{ab}Within the row means with no common superscripts differ significantly bearing at P<0.05.

were significantly higher in groups II and III than in group IV. In the second feeding period ME conversion was similar in all the groups. Significant ($P<0.001$) differences in energy conversion were observed between groups II and III and groups I and IV throughout the experiment. In both feeding periods and in the entire experiment total protein intake per kg weight gain in the experimental groups could be arranged in the following order: $I<II<III<IV$ ($P=0.001$).

Table 5. Effect of free-choice feeding on excreta dry matter (DM) content and footpad dermatitis (FPD) incidence in turkeys¹

Item	Group ²				SEM	P value
	I	II	III	IV		
Excreta DM (%)	22.0	20.1	20.2	20.9	0.370	0.232
FPD score (points)	1.45	1.77	2.06	1.73	0.121	0.384

¹Data represent mean values of 6 replications per treatment. SEM – standard error of the mean (SD divided by the square root of replication number, $n=24$).

²Group I – complete pelleted diet; other groups (II – ground-pelleted wheat, III – ground-pelleted wheat and whole grain wheat, IV – whole grain wheat) had free access to concentrate pellets.

FCF had no significant effect on excreta DM content and FPD incidence in 12-week-old turkeys (Tab. 5). During the testing period mortality rates were negligible and bird deaths (one in group I and one in group III) were not related to any specific dietary treatment.

According to several reports published in the 1990's whole grain diets may be successfully fed to poultry, because the birds select whole grains and pellets from the feed trough in the proportions that best meet their individual nutrition needs [Forbes and Covasa 1995, Gous and Swatson 2000]. However, other authors confirmed the above findings to a limited extent. Emmerson *et al.* [1990] found that turkey breeder hens fed in the FCF system consumed 10% less feed, 44% less protein and the same amount of energy compared with control birds fed a complete diet. In an earlier experiment of Cowan and Michie [1977] Large White male turkeys given a choice of concentrate containing 48.8% protein and either whole barley or oat consumed excess protein.

Our findings show that turkeys with similar BW consumed different amounts of protein and metabolizable energy, depending on the feeding system and the type feed offered. Turkeys that had free access to ground wheat and protein concentrate preferred the latter, which resulted in an increased daily total protein intake (by 6% on average, compared with group I). Turkeys fed whole grain wheat and protein concentrate on a free-choice basis consumed only small amounts of whole grain and large amounts of the concentrate, which increased their daily total protein intake by 27% compared with the control group fed a complete diet.

The results of several experiments indicate that broiler chickens make a sensible choice when given the option of choosing between diets differing in protein quality.

Gous and Swatson [2000] demonstrated that broiler chickens, when provided on a free-choice basis with two or three foodstuffs containing a single protein source, which could meet their requirements to some extent, effectively select a combination which maximizes their biological performance. According to Forbes and Shariatmadari [1994], laying hens seem less able than broilers to balance their protein intake when offered high-protein and low-protein foods, but it may be explained by the fact that mature birds learn more slowly than rapidly growing ones.

Considerable differences observed in our study in the consumption patterns of protein concentrate, ground-pelleted wheat and whole grain wheat, suggest that turkeys aged 5 - 8 weeks either need a longer time to fully adapt to FCF or are not able to adapt to FCF at all, especially when offered whole grain. Such a hypothesis is confirmed by the fact that the differences in daily total protein intake between the FCF groups and the control group were smaller in the second feeding period. Turkeys offered a choice between protein concentrate and whole grain wheat consumed only 11% total protein more than birds fed a complete diet, which could be indicative of their adaptation to FCF. Different results were reported by Majewska [1996], who studied feed intake in turkeys given, from five weeks of age, whole grain wheat and a complete pelleted diet, which protein content was 2-3% higher than recommended. In the cited study whole grain intake accounted for 23% of total feed intake and it was higher than in our experiment, most probably due to differences in the composition and protein content of the complete diet offered with whole grain.

According to some authors [Gous and Swatson 2000, Erener et al. 2006, Gabriel et al. 2008], FCF significantly improves the BW of chickens, hens and growing turkeys. In other experiments [Rose et al., 1995; Amerah and Ravindran, 2008] a decrease in the BW of broiler chickens was observed when whole wheat was offered with a balancer pellet or mash diet. Munt et al. [1995] studied the proportions of ingredients eaten by chickens given a free choice and found that their average live BW differed significantly depending on the method of feeding, in the descending order of pellets > mash > free choice.

After 4 and 8 weeks of feeding the BW of turkeys from the FCF groups were significantly lower than in group I fed a complete diet. In both feeding periods the birds given a free choice consumed more total protein per kg weight gain, in particular when whole grain wheat was included in the daily ration. An analysis of feed consumption patterns revealed that FCF resulted in poorer growth performance of turkeys due to an inadequate total protein intake, which was too low when the birds were given a free choice between protein concentrate and the preferred ground-pelleted wheat, and too high when protein concentrate (consumed in larger amounts) and whole grain wheat were fed in the free choice system.

At the beginning of the present experiment the average BW of birds (0.97 kg) was lower than that reported for male Hybrid Converter turkeys aged 4 weeks. In week 12, after feeding a complete pelleted diet, the BW of birds reached 10.48 kg and exceeded the standards for Hybrid Turkeys [2012]. This indicates that conventional feeding

supported the compensatory growth of turkeys, whose growth rate was reduced when they were given a commercial diet before the experiment. Such a fast growth rate was not observed in self-selecting turkeys, offered feed with a considerably increased protein content (protein concentrate and whole grain wheat) or ground-pelleted wheat that insignificantly (by 6% on average in the first feeding period) reduced their daily total protein intake.

FCF had no significant effect on excreta DM content or FPD incidence in 12-week-old turkeys, most likely because total protein intake was similar in all the groups in the second feeding period. High-protein diets lead to higher levels of nitrogen and water excretion, thus increasing the risk of FPD and breast blisters [Jankowski *et al.* 2012b].

The results of this study indicate that FCF resulted in poorer growth performance of turkeys due to an inadequate total protein intake, which was too low when the birds were given a free choice between protein concentrate and ground-pelleted wheat, and too high when protein concentrate and whole grain wheat were fed in the free choice system. Considerable disproportions in the consumption of protein concentrate and wheat, in particular whole grain wheat, suggest that turkeys aged 5-8 weeks either need a longer time to fully adapt to FCF or are not able to adapt to FCF at all.

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