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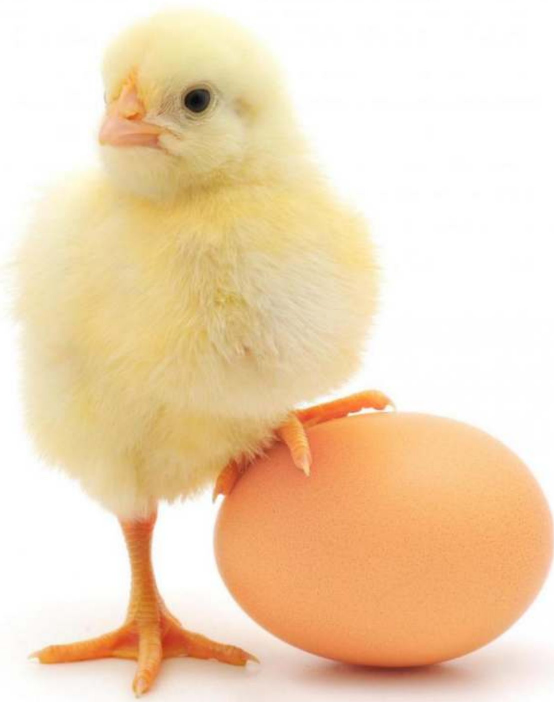

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Effects of Reduced Dietary Protein Concentrations with Amino Acid Supplementation on Performance and Carcass Quality in Turkey Toms 14 to 140 Days of Age

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Abstract: An experiment over five grow-out phases was conducted with male B.U.T. Big 6 turkeys from day fourteen to 140. Four dietary treatments differing in protein concentration and amino acid supply were employed. Treatment 1 represented current feeding practice with relatively high protein concentrations of 265 g/kg in phase two (3-5 weeks) feed which then was gradually reduced to 161g/kg in P-VI feed (18-22 weeks). In treatment 2 dietary protein was reduced by ten percent but all essential amino acids were balanced according to the amino acid profile of treatment 1. Diets fed in treatment 3 had also a ten percent reduced protein concentration but only Lys, Met+Cys, Thr, and Trp were balanced in feed formulation resulting in lower Arg, Val, Ile, and Leu concentrations compared to treatments 1 and 2. In treatment 4 crude protein was reduced by 20% but essential amino acids were balanced as in treatment 2. Results suggested that low protein diets with a protein reduction up to ten percent can be fed without adverse effects on animal performance and carcass traits provided the whole range of essential amino acids is balanced. It was concluded that Arg, Val, Ile, and Leu are important for optimum growth and should therefore be considered in diets containing 10% less crude protein. It was further concluded that in low protein diets providing sufficient amounts of essential amino acids the ratio between sum of all essential amino acids should not be higher than 48% of protein.

Key words: Turkeys, low protein diets, amino acid balance, carcass quality

Introduction

Turkey nutrition is characterized by high protein and amino acid supply in order to realize the high performance potential of current breeds. For example Lehmann *et al.* (1996,1997); Lemme *et al.* (2002) and Westermeier *et al.* (2000) impressively demonstrated the high requirement for dietary lysine and threonine to achieve optimum animal performance and profitability in male B.U.T. Big 6 turkey toms. This is in line to the results by Gramzow *et al.* (1998) and Gramzow (2001) who investigated the body growth development of male B.U.T. Big 6 turkeys as well as the accretion rate of specific tissues such as breast meat of these birds. Accordingly toms would achieve a body weight of 18kg with 18 weeks. In contrast, in 1980 final body weight at 18 weeks was only 12kg indicating an increased amino acid demand of modern turkey breeds. Maximum body growth rate occurred with 14 weeks of age while maximum breast muscle accretion rate took place in the 18th week (Gramzow *et al.*, 1998; Gramzow, 2001). These findings suggest a high amino acid requirement of current B.U.T Big 6 turkey toms for realizing their potential of weight gain and breast meat deposition not only in the starter phase but throughout the whole fattening period.

The goal to meet the amino acid needs of modern turkey breeds led to diet formulations with high protein contents of about 290g/kg in phase 1 (1-2 weeks of life) which then are gradually decreased to approximately 160g/kg in phase 6 feed (18-22 weeks of life). However, high protein intake leads inevitably to high nitrogen excretions which might contribute to environmental problems. One strategy to overcome this problem might be lowering the dietary protein concentration provided amino acid composition is balanced and optimized according to the turkey's requirement. Dose-response studies with turkeys examining single amino acid needs as well as research on optimum amino acid profiles has opened the possibility to establish low protein diets (e.g. Lehmann *et al.*, 1996, 1997; Lemme *et al.*, 2002; Westermeier *et al.*, 2000; Gramzow *et al.*, 1998; Gramzow, 2001). Therefore, the objective of the experiment presented here was to study the responses of male B.U.T Big 6 turkeys 14 to 140 days of age to reduced dietary protein concentrations which are balanced to a certain amino acid profile compared to a positive control representing current feeding practice.

Materials and Methods

In the experiment the dietary protein and amino acid supply, respectively, was varied. Four experimental diets were fed during the experimental phases lasting from

Table 1: Experimental design of the dose response trial with turkey toms 3 to 22 weeks of age

Treatment		Protein concentration in %					Replicates	Birds per Replicate
		P-II	P-III	P-IV	P-V	P-VI		
	Weeks	3-5	6-9	10-13	14-17	18-22		
1	Positive control	26.5	24.0	21.0	18.0	16.0	4	77
2	90 % CP - all*	23.9	21.6	18.9	16.2	14.4	4	77
3	90 % CP - FLA**	23.9	21.6	18.9	16.2	14.4	4	77
4	80 % CP - all*	21.2	19.2	16.8	14.4	12.8	4	77

*all essential amino acids were formulated to achieve at least the concentration of treatment 1

**FLA: only first limiting amino acids (Lys, Met+Cys, Thr, Trp) were considered in feed formulation in order to achieve the concentrations of treatment 1

week 3 to 5 (P II), 6 to 9 (P III), 10 to 13 (P IV), 14 to 17 (P V), and 18 to 22 (P VI), respectively (Table 1) while during week 1 and 2 (P I) birds of all treatments received the same commercial starter feed containing 11.4MJ ME/kg, 29% crude protein, 1.80 Lys, 1.15% Met+Cys, 1.16% Thr, 0.36% Trp, and 1.91% Arg, respectively.

The diets were based mainly on corn, wheat, and soybean meal (Table 2). In order to avoid variations in nutrient concentrations one batch per each ingredient was used per phase. Prior to feed production for the respective phases, samples of all protein containing ingredients were analyzed for dry matter, crude protein and amino acid composition. According to the results the diet formulations have been adjusted. No antimicrobial growth promoters were used. Because of relatively high proportions of wheat in the diets non-starch polysaccharides degrading enzymes were added. After manufacturing, representative samples of each diets were analyzed for amino acid composition. Amino acids were analyzed according to the methods of Llames and Fontaine (1994) and Fontaine *et al.* (1998). Results confirmed an accurate feed mixing with amino acid contents very close to the calculated figures.

All experimental diets were formulated to meet at least energy and amino acids concentrations as shown in Table 3. Thus, amino acid contents higher than given in Table 3 were possible (see Table 2). Treatment 1 represented current feeding practice (Moorgut Kartzfehn, 2002) and served as positive control. In treatment 2 the crude protein content was reduced by 10% compared to that of treatment 1 but all essential amino acids (Lys, Met+Cys, Thr, Trp, Arg, His, Ile, Leu, Phe, and Val) were offered in linear programming in order to achieve at least the same amino concentrations as given in Table 3. In treatment 3 the dietary protein content was also reduced by 10% compared to treatment 1 but only the commercially available amino acids (Lys, Met, Thr, Trp) were balanced whilst the remaining essential amino acids were not considered in feed optimization. In treatment 4 the dietary protein was reduced by 20% and least concentrations for the whole amino acid profile as given in Table 3 were applied.

All experimental diets were pelleted and produced at a commercial feed mill[1] and offered *ad libitum* (water as well).

A total of 1,232 two weeks old male B.U.T. Big 6 turkeys was used. However, 1,280 day old poults were purchased, equally distributed to the pens (80 birds/pen) and reared at the experimental farm. The poults originated from one hatch of one flock of parent birds and had an average weight of 53 g. At the beginning of the experimental phase the number of birds per pen was reduced to 77 by selecting the weakest turkeys and excluding them from the trial. Thus, the design comprised sixteen floor pens with 77 birds per pen and four pens per treatment.

Treatments were randomly distributed in an open sided animal house at the research facility of Moorgut Kartzfehn, Bösel, Germany. The lighting program was driven in accordance to the breeders recommendation (B.U.T., 2000). Minimum temperatures were also in agreement with the breeders recommendation while maximum temperatures were sometimes higher because the experiment was performed during summer 2002.

All pens were checked for sick and dead birds on a daily basis. However, the general health status was good and mortality was acceptable throughout the experiment. Until end of the experiment mortality was similar for each treatment and on average 10.7%.

Individual body weights were recorded for all birds at day fourteen and day 140. Body weights for a randomly selected number of fifteen toms per pen were determined at day 44, 69, and 120. These birds were not necessarily the same at each date. Feed consumption was determined for each phase on pen basis. Overall feed conversion was calculated and corrected for mortality by considering the body weight of died toms and outliers.

At the end of the experiment fifteen birds per treatment (randomly chosen from the pens) with body weights as close as possible to the treatment means were slaughtered for carcass evaluation. Turkey toms were slaughtered and dissected at a commercial slaughterhouse[2]. Apart from carcass weight, breast muscle (with skin), thigh, drum, wing as well as back fat weights were determined. Subsequently proportion of the cuts to carcass weight were calculated.

Table 2: Ingredients and nutrient composition (g/kg) of the experimental diets used in the grow-out phases P-II until P-VI

	P II (3-5 weeks of age)				P III (6-9 weeks of age)			
Treatment	1	2	3	4	1	2	3	4
Ingredients, g/kg								
Wheat	258	342	351	413	368	440	463	473
Corn	150	150	150	150	106	110	100	110
Soybean meal 48%	352	265	261	181	357	281	278	207
Full fat soybeans	140	140	140	140	50	50	50	51
Potato protein	10	10	10	10				
Soybean oil	18.5	12.3	10.0	9.8	15.4	10.0	6.3	11.7
Vegetable fat					28.2	28.2	28.2	30.2
Wheat bran					20.0	14.0	12.6	29.4
Dextrose	10.0	10.0	10.0	10.0				
DL-Methionine	2.8	3.6	3.6	4.4	2.5	3.2	3.2	3.9
L-Lysine Hcl	2.0	4.7	4.8	7.3	2.6	5.0	5.1	7.3
L-Threonine	0.3	1.6	1.6	2.9	1.1	2.2	2.3	3.4
L-Tryptophan		0.2	0.2	0.7		0.1	0.1	0.5
L-Valine		0.9		2.4		1.2		2.6
L-Arginine		2.3		4.7		1.9		4.1
L-Leucine		0.1		2.6		1.3		3.5
L-Isoleucine				1.4		0.1		2.1
L-Histidin Hcl				1.0		0.04		1.1
L-Phenylalanine				0.01				0.4
MCP	25.0	26.2	26.2	27.6	18.3	19.7	19.6	20.2
$CaCO_3$	20.0	20.1	20.1	20.1	19.1	19.2	19.1	19.5
Premix, (Vitamins, enzymes, filler, etc.)	11.4	11.0	11.5	11.1	11.8	12.9	12.5	19.1
Energy (MJ ME/kg) and nutrients (g/kg)								
Energy (MJ M E/kg)	11.6	11.6	11.6	11.6	12.0	12.0	12.0	12
Crude protein	265	239	239	212	240	216	217	193
Lysine	16.0	16.0	16.0	16.0	14.5	14.5	14.5	14.5
Methionine	6.3	6.7	6.7	7.1	5.6	6.0	6.0	6.3
Met + Cys	10.5	10.5	10.5	10.5	9.5	9.5	9.5	9.5
Threonine	10.1	10.1	10.1	10.1	9.6	9.6	9.6	9.6
Tryptophan	3.4	3.1	3.1	3.1	3.0	2.7	2.7	2.7
Arginine	17.5	17.4	15.0	17.4	15.7	15.5	13.5	15.5
Valine	12.4	11.7	10.8	11.7	10.9	10.8	9.6	10.8
Histidine	6.8	6.0	6.0	5.9	6.1	5.4	5.4	5.4
Isoleucine	11.4	9.9	9.8	9.8	10.0	9.4	8.6	9.4
Leucine	20.3	18.0	17.8	18.0	17.9	17.0	15.7	17.0
Phenylalanine e	13.2	11.5	11.5	9.9	11.7	10.2	10.2	9.1

	P IV (10-13 weeks of age)				P V (14-17 weeks of age)			
Treatment	1	2	3	4	1	2	3	4
Ingredients, g/kg								
Wheat	460	525	533	636	526	563	580	628
Corn	100	105	100	101	100	105	100	105
Soybean meal 48%	283	186	212	66	208	127	147	26
Full fat soybeans	30	30	30	30				
Peas	25	25	25	25	60	60	60	60
Soybean oil	1.5							
Vegetable fat	44.0	38.5	38.0	27.5	52.0	50.0	47.5	46.3
Wheat bran		20		20		30	7	50

Treatment	P IV (10-13 weeks of age) 1	2	3	4	P V (14-17 weeks of age) 1	2	3	4
DL-Methionine	2.3	3.1	2.9	4.2	2.1	2.8	2.6	3.7
L-Lysine Hcl	2.7	5.7	4.9	9.6	3.4	5.8	5.3	9.0
L-Threonine	0.7	2.2	1.8	4.0	0.9	2.1	1.8	3.6
L-Tryptophan		0.3	0.2	0.9		0.2	0.2	0.7
L-Valine		1.6		3.8		1.3		3.1
L-Arginine		2.5		5.9		1.8		4.7
L-Leucine		1.7		5.1		1.5		4.4
L-Isoleucine		1.3		3.4		1.3		3.1
L-Histidin Hcl		0.2		1.8		0.1		1.4
L-Phenylalanine				1.7				1.5
MCP	20.4	21.1	21.2	22.9	19.4	19.6	20.0	20.6
$CaCO_3$	19.0	19.3	19.2	19.5	16.6	16.9	16.9	17.9
Premix, (Vitamins, enzymes, filler, etc.)	11.4	11.5	11.8	11.7	11.6	11.6	11.7	11.0
Energy (MJ ME/kg) and nutrients (g/kg)								
Energy (MJ M E/kg)	12.3	12.3	12.3	12.4	12.6	12.6	12.6	12.7
Crude protein	211	189	190	169	181	163	162	145
Lysine	12.5	12.5	12.5	12.5	11.0	11.0	11.0	11.0
Methionine	5.0	5.4	5.3	6.0	4.4	4.7	4.6	5.2
Met + Cys	8.5	8.5	8.5	8.5	7.5	7.5	7.5	7.5
Threonine	8.0	8.0	8.0	8.0	6.9	6.9	6.9	6.9
Tryptophan	2.6	2.4	2.4	2.4	2.1	2.0	2.0	2.0
Arginine	13.4	13.2	11.5	13.2	11.1	10.7	9.5	10.7
Valine	9.5	9.4	8.2	9.4	7.9	7.8	6.9	7.8
Histidine	5.3	4.5	4.6	4.5	4.4	3.7	3.8	3.7
Isoleucine	8.5	8.1	7.3	8.1	7.0	6.9	6.0	6.9
Leucine	15.5	14.5	13.6	14.5	13.1	12.4	11.4	12.4
Phenylalanine e	10.1	8.3	8.8	7.6	8.4	6.5	7.3	6.5

Treatment	P VI (18-22 weeks of age) 1	2	3	4
Ingredients, g/kg				
Wheat	565	581	610	650
Corn	100	105	100	110
Soybean meal 48%	154	82	100	
Peas	65	65	65	56
Vegetable fat	64.8	66.8	61.3	64.8
Wheat bran		40	8.5	40
DL-Methionine	1.8	2.2	2.1	3.0
L-Lysine Hcl		5.3	4.8	8.1
L-Threonine	0.7	1.7	1.5	3.0
L-Tryptophan		0.3	0.2	0.7
L-Valine		1.0		2.6
L-Arginine		1.8		4.4
L-Leucine		1.1		3.5
L-Isoleucine		1.1		2.6
L-Histidin Hcl				0.8
L-Phenylalanine				1.2
MCP	18.1	17.9	18.5	19.3
$CaCO_3$	16.1	16.6	16.3	18.0
Sodiumbicarbonate				0.3
Premix, (Vitamins, enzymes, filler, etc.)	14.5	11.2	11.8	11.7

Treatment	P VI (18-22 weeks of age) 1	2	3	4
Energy (MJ ME/kg) and nutrients (g/kg)				
Energy (MJ M E/kg)	13.0	13.0	13.0	13.2
Crude protein	161	145	145	129
Lysine	9.5	9.5	9.5	9.5
Methionine	3.9	4.0	3.9	4.3
Met + Cys	6.7	6.5	6.5	6.5
Threonine	5.9	5.9	5.9	5.9
Tryptophan	1.9	1.8	1.8	1.8
Arginine	9.6	9.5	8.1	9.5
Valine	6.9	6.8	6.0	6.8
Histidine	3.9	3.2	3.4	2.9
Isoleucine	6.0	5.9	5.1	5.9
Leucine	11.6	10.7	10.1	10.7
Phenylalanine e	7.4	6.1	6.4	5.6

Before analysis weight gain (within pen) and carcass data was checked for outliers . All figures outside plus-minus two standard deviations were excluded from statistical treatment. Data sets were subjected to standard least square procedures of ANOVA and a comparison of means according to the LSD test (SAS, Release 8.01). For carcass data the individual bird served as experimental unit while for weight gain, feed intake, and feed conversion this was the pen. Results presented in the tables are given as means ± standard deviations. Treatment differences with $p < 0.05$ were considered statistically significant.

Results and Discussion

Animal performance data is shown in Table 4. Final weights ranged between 18.4 kg and 19.1 kg and feed conversion between 2.54 kg and 2.63 kg feed per kg gain. According to breeder's management guide (B.U.T., 2000) a final weight of 18.5 kg with a feed conversion of 2.77 could have been expected. Thus, the performance achieved was excellent across all treatments. However, highest body weights were achieved in treatment 1 representing current feeding practice. Treatments with a 10% reduced dietary protein content with or without completely balanced amino acid profile had slightly but not significantly lower performance (Treatments 2, 3). At 20% dietary protein reduction final weight was almost 700 g lower compared to those of the positive control. These effects on body weight could already be observed at day 44, 69, and 120 when fifteen randomly selected birds per pen were weighed (Table 5). Feed consumption seemed to decrease with decreasing dietary protein resulting in 3.3 kg lower feed consumption of turkey toms of Treatment 4 compared to Treatment 1 (Table 4). There was no consistent effect on feed conversion. Best feed conversion was observed in turkeys of treatment 4 which was about 7 points lower compared to that observed in the positive control and even 9 points lower to that recorded for treatment 3.

Data may suggest, that low protein diets (-10%) are possible alternatives to conventional diets in turkey nutrition in order to reduce nitrogen pollution provided the composition of all essential amino acids is balanced. One might argue, that performance recorded for Treatments 2 and 3 was - at least numerically - lower compared to that of Treatment 1 and that under practical conditions 200 g or even 400 g difference in final weight might be important. However, a closer look into the data provides some more information. In Fig. 1 the pen means are shown and it is noticeable that turkey toms of two pens belonging to treatment 2 performed equal or even better compared to turkeys of treatment 1 while the birds of the other two pens performed worse. The within treatment difference was even significant. Moreover, this trend seemed to be obvious already at day 69 but was not as clear at day 120 (Table 5). This unusual variation might have been a position effect within the animal house. Pens with lower performance, not only those of treatment 2 but partly also of treatments 3 and 4, were at the sunny side of the building. Since two pens had even a slightly higher average final weight the authors assume, that a 10% protein reduction at least with balancing the whole amino acid profile is possible without loosing animal performance. Veldkamp *et al.* (2000) reported a significant decrease in feed consumption leading to reduced weight gain at high ambient temperatures (30^{o}C) compared to low temperatures which might confirm the within treatment differences of treatment 2 in the present study. So, it is concluded, that diet or amino acid composition applied at least in Treatment 2 allows for the same performance as in the control group and is thus appropriate for low protein diets.

An explanation for the more obvious growth reduction in Treatment 3 where only the commercially available amino acids were considered in feed optimization might be derived from comparing the feed formulations of Treatments 2 and 3. Since the constraints in feed optimization for Lys, Met, Met+Cys, Thr, and Trp were identical in both formulations, there were absolutely no differences between both diets regarding these amino acids (Table 2). However, the Arg, Val, Ile and Leu concentrations were clearly reduced in the diets of treatment 3 compared to those of treatment 2. These reductions ranged between 6 and 15% through all phases and were most pronounced for Arg. It may be speculated that one of these amino acids limited performance in treatment 3. At this point no clear statement could be made which of the four amino acids Arg, Val, Ile, and Leu limited performance when crude protein was lowered by 10%.

Scientific information about turkey responses to Arg, Val, Ile, and Leu is scarce. Veldkamp *et al.* (2000) investigated the effects of dietary Arg concentration in male turkeys from day 28 to 140 and reported that growth performance was not affected by an increased Arg supply at either temperature. In that experiment Lys, Met+Cys, and Thr concentrations were comparable to those in the present study but the lowest Arg concentration was always kept at 100% in relation to Lys and was thus not as low as in treatment 3 of the present study and possibly not limiting performance at all. Waldroup *et al.* (1998) conducted Arg dose response studies over 18 weeks with male turkeys even at three dietary Lys concentrations. While the two lower lysine concentrations of that experiment were clearly lower, the highest lysine concentration was comparable to the present experiment. However, the basal Arg concentration was as high or even lower (depending on the phase) compared to the concentrations reported here for treatment 3 but they did not observe an Arg dose-response effect on growth, feed conversion, or carcass quality. Piffrader *et al.* (1999) reported a trial with turkeys lasting 78 days and they also found no beneficial effect of increasing Arg supplementation on weight gain, feed conversion, or carcass traits. Particularly the latter

Table 3: Least energy (MJ ME/kg) and amino acids (g/kg) contents used in linear feed programming for the experimental diets fed during the consecutive grow-out phases P-II, P-III, P-IV, P-V, and P-VI*

Weeks	P II 3-5	P III 6-9	P VI 10-13	P V 14-17	P VI18-22
Energy (MJ M E/kg)	11.6	12.0	12.3	12.6	13.0
Lysine	16.0	14.5	12.5	11.0	9.5
Methionine	6.2	5.6	5.0	4.4	3.9
Met + Cys	10.5	9.5	8.5	7.5	6.5
Threonine	10.1	9.6	8.0	6.9	5.9
Tryptophan	3.1	2.7	2.4	2.0	1.8
Arginine	17.4	15.5	13.2	10.7	9.5
Valine	11.7	10.8	9.4	7.8	6.8
Histidine	5.9	5.4	4.5	3.7	2.9
Isoleucine	9.8	9.4	8.1	6.9	5.9
Leucine	18.0	17.0	14.5	12.4	10.7
Phenylalanine e	9.9	9.1	7.6	6.5	5.6

* In treatment 3 only constraints for Lys, Met+Cys, Thr, and Trp were used.

Table 4: Final body weight, cumulated feed conversion and carcass quality of male B.U.T. Big 6 turkeys 140 days of age which were fed diets differing in protein and amino acid supply

	Treatment 1		Treatment 2		Treatment 3		Treatment 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Final weight, kg*	19.11^{A}	±0.09	18.90^{AB}	±0.59	18.71^{AB}	±0.46	18.43^{B}	±0.39
Feed consumption, kg/bird	52.41^{A}	±1.00	51.22^{AB}	±1.44	51.39^{AB}	±1.66	49.16^{B}	±2.67
Feed per gain	2.609^{A}	±0.021	2.593^{AB}	±0.029	2.632^{A}	±0.044	2.538^{B}	±0.060
Carcass weight, kg	13.89^{A}	±0.12	13.86^{A}	±0.28	13.62^{B}	±0.40	13.19^{B}	±0.34
Carcass yield, % of LW	72.5^{A}	±0.65	72.4^{A}	±1.35	72.7^{A}	±1.93	71.24^{B}	±0.85
Breast, %**	37.66^{A}	±1.72	37.08^{A}	±2.34	35.41^{B}	±1.16	34.89^{B}	±1.16
Drums, %**	13.57^{B}	±0.79	13.46^{B}	±0.63	13.92^{AB}	±0.77	14.17^{A}	±0.63
Thighs, %**	17.20^{C}	±0.80	18.24^{A}	±0.67	18.09^{AB}	±1.10	17.60^{BC}	±0.68
Wings, %**	10.64^{B}	±0.35	11.28^{A}	±0.35	11.31^{A}	±0.29	11.29^{A}	±0.65
Backfat, %**	0.77	±0.17	0.59	±0.16	1.14	±0.15	0.89	±0.13

*: different superscripts (^{A,B,C}) within a row indicate significant differences with $p< 0.05$ (LSD test)

**: in % of carcass weight.

both studies suggest that in the present study Arg might not have been the limiting factor for birds performance of treatment 3 leaving Val, Ile and Leu as possible limitation factors.

Mack *et al.* (1997) presented an experiment where protein was reduced by 10% in P-IV and P-VI feed with a very similar composition of the essential amino acids except for Thr which was lower. Supplementing Thr had beneficial effects on weight gain and breast meat yield suggesting, that threonine was limiting performance. However, additional supplementation of L-Val, L-Ile and L-Leu (in P-IV feed) had no additional effect on the investigated criteria and the authors concluded that Val, Ile, and Leu were not limiting performance which is in contrast to the above made conclusion to the present data set.

According to the data provided by two experiments performed by Waibel *et al.* (2000a) one can draw the conclusion, that either Arg, Ile, or Val is next limiting after Lys, Met+Cys, Thr, and Trp. Only when Arg, Ile, and Val were supplemented to low-protein diets, weight gain in male B.U.T. Big 6 turkeys returned to that concentration achieved with the control diets. Similar findings were reported in further experiments by Waible *et al.* (2000b). In contrast to the weigh gain data, carcass weight was reduced only by a 20% protein reduction (Table 4). Carcass yield in Treatment 4 was depressed by more than one percentage point compared to the figures determined for treatments 1, 2, and 3. The effects of protein reduction and amino acid supplementation were more pronounced with respect to breast meat yield. Breast meat yield was 6.0% lower in turkeys of treatment 3 and 7.4% lower in toms of treatment 4 compared to the control giving again an indication, that Arg, Val, Ile, and Leu might play an important role in terms of protein accretion and performance limitations. Although ANOVA detected significant effects of treatments on the remaining carcass traits as thigh, wings, and back fat percentage the results were not as consistent as found for breast meat or carcass yield.

Table 5: Body weights of fifteen randomly selected B.U.T Big 6 turkey toms per pen determined (kg/bird) at 44, 69, and 120 days of age*

	Treatment 1		Treatment 2		Treatment 3		Treatment 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Day 44								
1	2.46	±0.24	2.46	±0.25	2.25	±0.21	2.32	±0.26
2	2.50	±0.23	2.45	±0.24	2.41	±0.20	2.30	±0.18
3	2.49	±0.24	2.44	±0.23	2.50	±0.25	2.40	±0.26
4	2.68	±0.18	2.31	±0.35	2.48	±0.28	2.26	±0.17
Mean	2.53	±0.24	2.42	±0.27	2.41	±0.25	2.32	±0.22
Day 69								
1	6.09	±0.55	5.89	±0.77	5.72	±0.44	5.54	±0.52
2	5.92	±0.53	5.83	±0.51	5.89	±0.53	5.80	±0.54
3	5.81	±0.39	5.69	±0.46	5.52	±0.53	5.39	±0.45
4	6.05	±0.47	5.68	±0.45	5.66	±0.49	5.38	±0.39
Mean	5.97	±0.49	5.77	±0.55	5.70	±0.50	5.53	±0.50
Day 120								
1	16.37	±0.84	15.52	±1.23	15.03	±1.09	15.09	±1.03
2	15.91	±1.10	16.34	±0.59	15.74	±0.91	15.72	±1.51
3	15.40	±0.60	15.38	±1.04	15.16	±1.17	15.23	±0.94
4	16.03	±1.02	14.55	±0.70	15.14	±0.76	14.52	±1.09
Mean	15.93	±0.95	15.45	±1.11	15.27	±1.01	15.14	±1.21

* No ANOVA or comparison of means was performed.

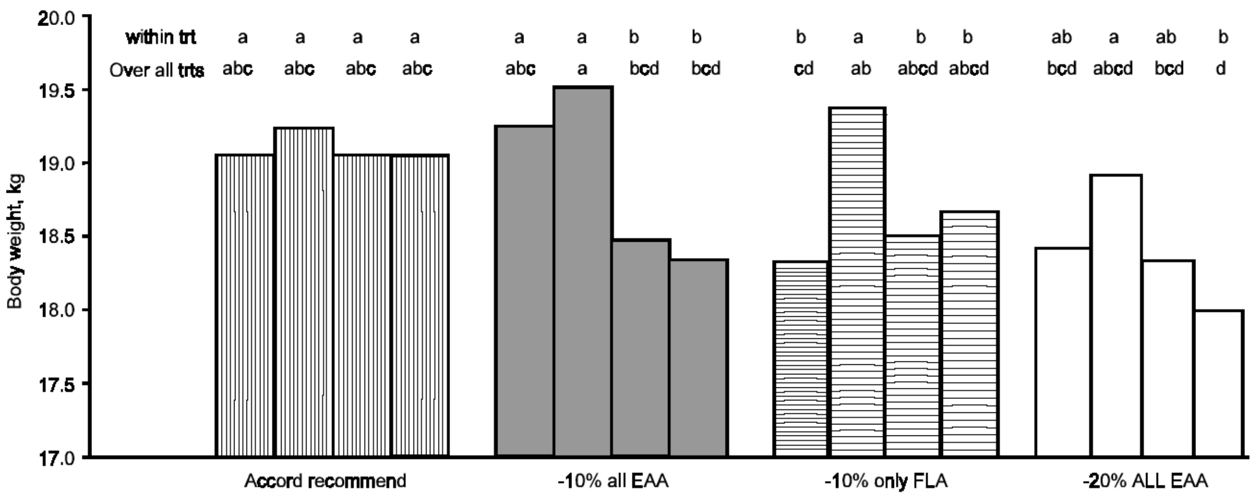

Fig. 1: Variation within treatments on final body weight of male turkeys at 140 days of age*
*different letters per row indicate significant differences, $p<0.05$.

The reduction in breast meat yield by treatment 3 is confirmed by Mack *et al.* (1997) who fed low protein diets (14.5%) to 17 to 20 weeks old turkey toms and who observed a four percentage reduction. In contrast to Lehmann *et al.*'s (1997) conclusion that for optimum breast meat yield higher Thr concentrations are needed than for weight gain, breast meat yield improved only marginally with additional Thr in low-protein treatments in the study by Mack *et al.* (1997). These findings again suggest that Arg or/and the branched chain amino acids play a role for optimum protein accretion. With respect to dietary Arg Piffrader *et al.* (1999); Veldkamp *et al.* (2000), and Waldroup *et al.* (1998) did not observe any effect of increasing Arg concentrations on breast meat yield. But even with Arg, Ile, and Val supplementation to low protein diets breast meat yield could not be returned to the concentration of the positive control as reported by Waibel *et al.* (2000a). Although recommending similar amino acid profiles as realized in treatments 1 and 2 it can be concluded from the data given by Waldroup *et al.*

(1997), that for optimum breast meat yield higher amino acid and protein concentrations are required than for weight gain. This is confirmed at least for single amino acids by Lehmann *et al*. (1997, 1996). However, in the present study breast meat yield could be maintained at a 10% protein reduction when the whole amino acid profile was balanced. This indicates that protein reduction up to 10% is possible even with respect to carcass quality; but the importance of Arg, Ile, Leu, and Val for breast muscle development is also obvious in treatment 3.

At 20% protein reduction using the amino acid concentrations as given in Table 3 failed to maintain animal performance at the concentration achieved by the control turkeys. Obviously protein as such and the proportion of non-essential amino acids in protein, respectively, was too low. The essential amino acids to protein ratio (EAA:CP) ranged between 51 and 54% in diets of treatment 4 whereas EAA:CP ranged between 46 and 48% in diets used in treatment 2 or was even lower in treatment 1. It appears, that in the present study EAA:CP of treatment 4 exceeded a certain threshold compared to treatment 2 preventing optimum growth. Bedford and Summers (1988) varied the EAA:CP in turkey starter diets (P-I) at three protein concentrations and observed best performance at an EAA:CP of 56% (recalculated to make it comparable) while decreasing it to 47% or even to 33% but also increasing to 66% clearly impaired weight gain, feed intake, and protein accretion. Reducing dietary protein from 300 g/kg to 260 g/kg or 220 g/kg decreased performance and protein accretion at each EAA:CP but, however, no interaction between EAA:CP and protein concentration was stated. It seems to be important whether EAA:CP is varied by the proportion of the essential or non-essential amino acids.

Regarding the data presented it is concluded, that a 10% dietary protein reduction in relation to current feeding practice throughout all grow-out phases is basically possible without adverse effects on body weight, carcass, and breast meat yield provided all essential amino acids are balanced as suggested in Table 3. Presented data suggest, that Arg, Val, Leu, and Ile become important in diets with a l0% protein reduction. Using the given amino acid profile and amino acid concentrations listed in Table 3 optimum essential amino acid to protein ratio should not exceed 48% by protein reduction.

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Abbreviation Key: Arg: Arginine; EAA:CP:Essential amino acids to crude protein ratio; His: Histidine; Ile: Isoleucine; Leu: Leucine; Lys: Lysine; Met+Cys: Methionine plus cysteine; Phe: Phenylalanine; Thr: Threonine; Trp: Tryptophan; Val: Valine.

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