Experimental study on the requirement of threonine in finishing pigs

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Experimentelle Untersuchungen zum Threoinbedarf von Mastschweinen in der Endmast

1 Introduction

Over the last decades, the chemical body composition of growing pigs has considerably changed. DREISHING (1999) reported that, on a fresh matter basis, modern genotype pigs showed 10 % lower body crude fat concentrations than 20 years ago but the protein content increased about 1 % in the same time period. Those changes in the pig's capacity for percentage lean meat deposition, however, may heavily influence amino acid requirements. Therefore requirement estimates derived from past work have to be continuously reevaluated.

The knowledge of the exact requirement of essential amino acids is crucial for a contemporary feeding of pigs. For example, this knowledge allows a protein reduction in the diets with simultaneous supply of crystalline amino acids. Those feeding strategies reduce nitrogen output in pig production and besides the positive effects on the environment they are capable to save feeding costs. Therefore, scientific societies give amino acid requirements recommendations for a certain level of production. Current requirement estimates for the optimum threonine:lysine (Thr:Lys) ratio in finishing pigs range from 0.60:1 (GFE, 1987) to 0.68:1 (NRC, 1998), based on gross amino acid

Zusammenfassung

Das Ziel der Untersuchung war es den Threoninbedarf von modernen österreichischen Masthybriden in der Endmast zu ermitteln. 24 männliche Kastraten und 36 weibliche Tiere wurden während einer durchschnittlichen Endmastdauer von 48 Tagen isonitrogen (13.4% Rohprotein) gefüttert. Der Unterschied in den Rationen lag lediglich im Threoningehalt, wobei es 6 Abstufungen gab. Im Vergleich mit der Kontrollgruppe (4.4 g/kg Threonin) verbesserte eine Threoninkonzentration von 5.7 g/kg die Tageszunahmen um 9 Prozentpunkte (p<0.05) und die Futterverwertung um 8 Prozentpunkte. Der Harnstoffgehalt im Blutplasma, die Ergebnisse der Schlachtleistung und der Fleischqualität zeigten keine signifikanten Unterschiede zwischen den Versuchsgruppen. Aus den Ergebnissen der Mastleistung kann geschlossen werden, dass das optimale Verhältnis von Thr:Lys bei 0.68 oder höher liegt.

Schlagworte: Aminosäuren, Threonin, Mastschweine in der Endmast, Mastleistung, Schlachtleistung.

Summary

The objective of this study was to determine the threonine requirement of a modern growing pig crossbred from Austria in the finisher stage. For on average 48 days, 24 castrated male and 36 female pigs with a mean initial body weight of ±68 kg, were fed isonitrogenous diets (13.4% crude protein) supplemented with 6 levels of crystalline threonine. A dietary threonine concentration of 5.7 g/kg improved daily gains by about 9 percentage points (p<0.05) and the feed conversion ratio by about 8 percentage points, as compared to the control group (4.4 g/kg threonine), and therefore a clear dose-response effect was shown. The plasma urea concentration, carcass characteristics and meat quality showed no significant differences between the treatments. Based on the results of the growth performance, the optimum dietary Thr:Lys ratio in the finisher stage of pigs is estimated to be at least 0.68.

Key words: Amino acids, threonine, finisher pigs, growth performance, carcass characteristics.

contents. Consistent with this wide range of recommended dietary Thr supply, a recent detailed review of research estimating the Thr requirement in starting and finishing pigs revealed a high variability and moreover a lack of empirical data (GUZIK, 2005). For this reason, a dose response study was conducted to determine the optimum Lys:Thr ratio in modern finishing Austrian crossbred pigs.

2 Materials und Methods

2.1 Animals and housing

The study employed a total of 60 finishing Austrian crossbred (OEHYB) pigs. The animals arrived at the experimental station (Austrian Pig Testing Facility, Streitdorf) with an average body weight of 30 kg and were distributed equally among 12 pens of 5 animals each (2 pens of 5 pigs per experimental group), considering sex (4 castrated male and 6 female pigs per group), litter and body weight. The pigs were housed in a fully air-conditioned piggery at a room temperature of 20–22 °C. Each pen was equipped with an automatic dry-feeding-system and a nipple drinking system.

2.2 Diets and feeding

During an adaptation period of 10 days, animals received a common medical diet (H 427 MED., Hofer KG) for prophylaxis. Subsequently, all animals were fed a grower diet mainly based on corn, extracted soybean meal and barley (Table 1), providing all nutrients according to current recommendations (GFE, 1987) until the start of the experiment. Pigs were allowed to consume the pelleted feed and water ad libitum.

When animals of each box reached on average 70 kg body weight (between day 50 and 52), the feed was switched to the 6 pelleted experimental finisher diets which were based on the same components as the grower diet. Animals of a first treatment (treat) group received a low protein basal diet (13.4 % crude protein (CP)), deficient in Thr concentration (4.4 g/kg by analysis, Table 2) as compared to current recommendations (NRC, 1998). For animals of the remaining groups (treat 2 to 6), this basal diet was supplemented with graded levels of L-Thr. Analysed Thr concentrations of diets 2 to 6 were 4.6, 4.7, 5.1, 5.3 and 5.7 g/kg, respectively. For all diets, L-LysHCl was added to give an adequate Lys supply of 0.63 g Lys/MJ ME (RADEMACHER et al., 2001). DL-Met and L-Trp were supplemented to give a ratio of Lys:Met+Cys:Trp of 1:0.67:0.2 according to the concept of the ideal protein (RADEMACHER et al., 2001). Calculated energy and CP contents were 13.4 MJ ME/kg and 13.4 %, respectively.

The 6 dietary treatments were equally distributed among the 12 pens, considering possible environmental influences (e.g. terminal pen). Feed intake of each animal was recorded daily by a transponder system. Individual body weight was recorded weekly.

During the growing phase, 7 casualties occurred due to pneumonia, while no further problems occurred during the entire finishing phase.

Table 1: Composition of grower and finisher diet
Tabelle 1: Zusammensetzung des Anfangs- und Endmastfutters

Component		Grower diet	Finisher diet
Maize	%	33.8	32.0
Soybean meal, extracted	%	19.5	7.7
Barley	%	20.0	14.0
Oil (Linol 20)	%	2.0	0.5
Wheat bran	%	5.0	4.0
Wheat	%	16.0	38.3
Mineral and vitamin supplement	%	3.35[1)]	3.07[2)]
L-lysine	%	0.275	0.370
DL-methionine	%	0.050	0.050
L-threonine	%	0.075	–
L-tryptophan	%	0.010	0.030
Calculated nutrients			
ME	MJ/kg	13.27	13.42
Crude protein	%	17.8	13.5
Ether extracts	%	4.6	3.1
Crude fibre	%	3.5	3.1
Lys	g/kg	10.5	8.2
Met	g/kg	6.6	5.5
Thr	g/kg	7.0	4.5
Trp	g/kg	2.2	1.8

1) Provided the following per kg of diet: 8.9 g Ca, 6.3 g P, 1.65 g Na, 1.55 g Mg, 9.59 mg Cu, 129 mg Fe, 3.63 mg J, 38 mg Mn, 0.42 mg Se, 80 mg Zn, 12000 IU vitamin A, 2000 IU vitamin D_3, 336 mg vitamin E, 1.2 mg vitamin K_3, 4.0 mg vitamin B_1, 4.1 mg vitamin B_2, 4.3 mg vitamin B_6, 18 Ìg vitamin B_{12}, 51 mg nicotinic acid, 21 mg panthotenic acid, 1529 Ìg folic acid, 870 mg choline chloride, 229 µg biotin

2) Provided the following per kg of diet: 8.1 g Ca, 6.0 g P, 1.55 g Na, 1.84 g Mg, 8.0 mg Cu, 37 mg Mn, 0.41 mg Se, 77 mg Zn, 12000 IU vitamin A, 2000 IU vitamin D_3, 88 mg vitamin E

2.3 Sampling and chemical analyses

The animals were slaughtered under standardized conditions in the slaughter-house of the Pig Testing Facility when individual body weight of animals reached 110 kg. The slaughtering took place once a week after fasting the animals for 12 h. In total, 6 slaughter dates were included.

Blood samples were retrieved during bleeding and blood plasma was separated immediately by centrifugation. At the day of slaughter and the following day, carcass characteristics and meat quality parameters were assessed according to the guidelines of the Austrian Pig Testing Facility (BGBL. II, 1967; BRANSCHEID et al., 2007).

All diets were analysed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extracts (EE), ash, starch and sugar (Table 2) according to standard methods (NAUMANN and BASSLER, 1976). Concentration of metabolizable energy (ME) was calculated according to GFE (1987). Amino acid composition of the finisher diets was analysed according to NAUMANN and BASSLER (1976). Plasma urea concentration was analyzed on a spectral photometer (340 nm) using a commercial test kit (R-Biopharm, Darmstadt, Germany).

2.4 Statistical analysis

The GLM procedure of SAS (SAS Inst., Inc., Cary, NC) was used to determine treatment effects by analysis of variance (ANOVA) using a randomized complete block design. The treatments were included in a 3 factorial arrangement to test the dietary concentration of Thr, sex, litter and interactions of Thr x sex, Thr x litter and Thr x sex x litter. The initial body weights were used as covariates for analysis of growth performance. Means of each treatment were compared using the Student-Newman-Keuls test for each variable. The following tables present the mean values of the different Thr levels and the pooled standard error (S.E.)

Table 2: Analysed chemical composition of the finisher diets
Tabelle 2: Chemische Analyse der Inhaltsstoffe des Endmastfutters

Nutrients (g/kg feed)	treatment					
	1	2	3	4	5	6
Dry matter	898	897	894	898	895	898
Crude protein	134	133	133	134	135	134
Ether extracts	30	31	30	32	30	31
Crude fiber	34	42	34	42	47	50
Ash	47	44	46	47	48	46
Starch	521	523	526	505	515	514
Sugar	31	30	32	31	32	32
ME (MJ/kg)	13.74	13.66	13.77	13.51	13.50	13.49
Amino acids (g/kg feed)						
Lys	7.9	8.1	8.0	8.3	8.2	8.4
Thr	**4.4**	**4.6**	**4.7**	**5.1**	**5.3**	**5.7**
Met	2.5	2.5	2.5	2.6	2.5	2.6
Cys	2.5	2.4	2.4	2.4	2.4	2.4
Met+Cys	5.0	4.9	4.9	5.0	4.9	4.9
Try	1.7	1.8	1.8	1.8	1.8	1.8
Ile	4.7	4.7	4.7	4.8	4.7	4.7
Leu	10.0	10.2	10.3	10.4	10.3	10.3
Val	5.8	5.9	5.9	6.0	5.8	5.9
Arg	7.0	7.0	7.0	7.1	7.0	7.1
His	3.1	3.0	3.0	3.0	3.0	3.0
Phe	6.1	6.0	6.0	6.1	6.0	6.1
Tyr	4.0	3.9	3.9	3.9	3.9	4.0
Ser	6.0	5.9	5.9	6.0	6.0	6.0
Ala	6.0	6.0	6.1	6.1	6.1	6.1
Asp	9.5	9.4	9.5	9.7	9.6	9.6
Glu	27.6	27.7	27.4	27.8	27.5	27.7
Gly	5.3	5.2	5.2	5.3	5.2	5.3
Pro	9.8	9.4	9.5	9.7	9.6	9.6
Lys:Thr	***0.56***	***0.57***	***0.59***	***0.61***	***0.65***	***0.68***

derived from the analysis of variance. Significant differences among means ($p<0.05$) are indicated by superscripts.

A non-linear regression procedure (LITTELL et al., 1997) with means for treatments was used to determine the Thr requirement of pigs. The exponential model was fitted to the experimental data using the non-linear procedure of SAS. The tentative values for the optimum dietary Thr concentration were calculated at 90 % of the asymptotic response. The coefficient of determination (R^2) was used to assess the goodness of fit for the model.

3 Results

As shown in Table 3, growth performance was highly influenced by dietary Thr concentration. At lower dietary Thr concentrations there was no dose-response relationship between Thr supply and growth and pigs fed diets containing 4.6 and 5.1 g Thr/kg had lower ($p<0.05$) growth rates than pigs fed diets containing 4.4 or 4.7 g Thr/kg, respectively. A dietary Thr concentration of 5.3 g/kg, however, improved ($p<0.05$) daily gains by about 8 percentage points as compared to the unsupplemented control group. A further increase of Thr supply from 5.3 to 5.7 g/kg increased daily gains only marginally. As a result of marginal variations of initial body weight between treatment groups and the differences in daily gains, time to reach the desired final weight (days on experiment) tended to be lower (4 to 6 days) at the highest supplementation level as compared to the remaining groups. Mean daily feed intake was 2.6 kg and showed only minor treatment differences. Lowest values were observed at a dietary Thr concentration of 4.6 g/kg (2.47 kg/d) and highest values at a dietary Thr concentration of 5.3 g/kg (2.74 kg/d). As a result of increasing dietary Thr concentrations and a comparable feed intake in different treatment groups, daily Thr intake increased in a linear manner from 11.4 g in the unsupplemented group to 15.0 g at the highest Thr supplementation level. Comparable to daily gains, there was no clear dose-response relationship between Thr supply and feed to gain ratio. Nevertheless, compared to pigs fed diets containing 4.6 or 5.3 g Thr/kg feed, feed to gain ratio at the highest supplementation level (2.52 g/g) was clearly ($p<0.05$) improved by about 10 percent, whereas pigs at the remaining treatment groups had intermediate feed to gain ratios. Mean plasma urea concentration was 3.7 mmol/l and showed no significant differences between treatments. Nevertheless, plasma urea concentration of 4.4 mmol/l at a dietary Thr concentration of 4.4 g/kg tended to decrease up to a dietary Thr concentration of 4.7 g/kg, where a plateau level of plasma urea concentration of about 3.6 mmol/l was observed. Derivation of optimum Thr supply by non-linear regression analysis indicated a dietary Thr level of 4.8 g/kg diet (R^2 = 0.95) for to minimize plasma urea concentration.

Carcass characteristics are given in table 4, 5 and 6. For all treatment groups a high dressing percentage of on average 80 % was observed. Moreover, a good carcass quality as characterized by a lean meat percentage of on average 58 %, a longissimus muscle and fat area of 57 and 16.5 cm^2, respectively, was observed, but there was no influence of dietary treatment. Comparable to data of carcass quality, dietary Thr supply did not influence parameters of meat quality (Table 6).

4 Discussion

4.1 Growth performance

The objective of the present experiment was to determine the optimum dietary Thr:Lys ratio for finishing pigs using a dose-

Table 3: Growth performance and plasma urea concentration
Tabelle 3: Mastleistungsergebnisse und Harnstoffkonzentration im Blutplasma

Dietary threonine (g/kg feed) Treatment		4.4 1	4.6 2	4.7 3	5.1 4	5.3 5	5.7 6	S.E.
Number of pigs	n	9	8	10	9	9	8	–
Days on experiment	d	47.7	50.4	48.4	47.9	48.3	44.1	8.6
Initial weight	kg	68.4	68.7	67.2	70.3	64.6	68.3	7.1
Final weight	kg	113.3	112.8	112.9	113.2	113.8	113.4	2.2
Daily growth rate	g	951^{b}	885^{c}	950^{b}	915^{c}	1024^{a}	1046^{a}	83
Daily feed intake	g/d	2584	2469	2564	2548	2741	2627	228
Feed conversion (feed/gain)	g/g	2.72^{ab}	2.80^{a}	2.69^{ab}	2.79^{a}	2.67^{ab}	2.52^{b}	0.18
Blood plasma urea	mmol/l	4.4	3.8	3.6	3.6	3.6	3.4	0.96

[a, b, c)] Means of the same parameter without common superscripts differ at $p<0.05$

Table 4: Carcass measurements
Tabelle 4: Schlachtleistung

Dietary threonine (g/kg feed) Treatment		4.4 1	4.6 2	4.7 3	5.1 4	5.3 5	5.7 6	S.E.
Warm carcass weight	kg	91	90	91	91	91	90	2.51
Dressing[1)]	%	79.9	79.8	80.1	80.1	78.9	79.3	1.3
Weight of the cold left carcass side	kg	44.5	43.9	44.5	44.5	44.3	44.3	1.29
Head	kg	2.07	2.06	2.04	2.02	3.01	2.01	0.11
Neck	kg	1.31	1.29	1.38	1.36	1.27	1.31	0.10
Shoulder	kg	6.91	7.00	6.82	6.88	6.92	7.08	0.28
Belly	kg	8.13	7.80	7.83	8.15	8.01	7.95	0.39
Loin	kg	10.24	10.16	10.37	10.32	10.09	10.01	0.51
Dissected loin fat	kg	2.14	2.15	2.30	2.24	2.26	2.04	0.24
Ham	kg	12.11	11.93	12.24	11.90	12.08	12.36	0.49
Dissected ham fat	kg	1.45	1.45	1.46	1.52	1.55	1.39	0.23
Body length	cm	100.9	102.2	101.4	99.6	99.3	100.2	2.19

1) Weight of warm carcass weight expressed as a percentage of slaughter weight

Table 5: Carcass composition
Tabelle 5: Schlachtkörperzusammensetzung

Dietary threonine (g/kg feed) Treatment		4.4 1	4.6 2	4.7 3	5.1 4	5.3 5	5.7 6	S.E.
Lean	%	60	58	58	57	58	59	1.9
Valuable cuts	%	50.2	50.3	50.8	50.0	50.1	50.5	1.4
Fat-Meat relation	1: …	6.4	6.5	6.2	6.4	6.1	6.7	0.9
Back fat thickness	mm	22.78	21.13	22.20	24.67	23.89	22.63	3.10
Meat thickness	mm	76.00	76.25	76.10	76.67	76.78	76.50	4.35
Longissimus muscle area	cm^2	56.6	55.3	57.8	58.2	57.0	56.3	4.06
Longissimus fat area	cm^2	16.1	15.9	16.8	17.8	17.1	15.5	2.46

Table 6: Meat quality traits
Tabelle 6: Fleischqualität

Dietary threonine (g/kg feed) Treatment		4.4 1	4.6 2	4.7 3	5.1 4	5.3 5	5.7 6	S.E.
Loin ph. 60 min[1)]		5.99	5.95	5.90	6.13	6.09	5.86	0.23
Ham ph. 60 min[1)]		6.15	6.18	6.18	6.31	6.05	6.06	0.34
Loin conductivity. 60 min[2)]	mS/cm	3.81	4.85	4.35	3.63	4.00	4.93	1.46
Ham conductivity. 60 min[2)]	mS/cm	4.90	3.55	4.61	4.10	6.73	4.63	2.88
Loin conductivity. 24 h[3)]	mS/cm	4.42	4.76	5.10	3.99	3.90	4.38	1.45
Ham conductivity. 24 h[3)]	mS/cm	7.73	6.93	5.10	7.24	8.20	8.16	3.05
Loin lightness (U)[4)]		60.56	61.38	57.80	60.11	59.56	59.13	3.66
Drip loss[5)]	%	4.74	5.24	4.54	4.26	4.41	4.89	1.54
Intramuscular fat	%	0.75	0.67	0.69	0.73	0.65	0.65	0.27

1) Optimum: ph 60 min >6.0
2) Optimum: loin and ham conductivity <5.0 mS/cm
3) Optimum: loin and ham conductivity <8.0 mS/cm
4) "Göttinger Farbhelligkeitsmesser" <45 U = PSE. >80 U = DFD (U = units)
5) Optimum: drip loss 3 to 5 %

response assessment. For this purpose, pigs of treatments 1 to 4 were given diets expected to be clearly deficient in Thr concentration (NRC, 1998), whereas dietary Thr concentrations of treatments 5 and 6 were set at or above current requirement estimations for finishing pigs (NRC, 1998; GfE, 1987). Surprisingly, in the Thr deficient treatments (treat 1 to 4) there was no clear relationship between dietary Thr supply and growth or feed to gain ratio. On the contrary, animals of treat

1 and 3 (4.4 and 4.7 g Thr/kg diet) had better (p<0.05) growth rates and lower feed to gain ratios than animals of treat 2 or 4 (4.6 or 5.1 g Thr/kg diet). Those results, which seem to be related to other, unknown factors rather than to the Thr supply complicate the derivation of an optimum dietary Thr:Lys ratio by the use of regression methods. Nevertheless, it is obvious that a further increase of dietary Thr concentration up to 5.3 and 5.7 g/kg, respectively, significantly (p<0.05) increased daily gains by at least 8 %. Moreover, best feed conversion ratio as well as lowest time span to reach the desired end weight of 110 kg were observed at a dietary Thr concentration of 5.7 g/kg, and therefore at the highest dietary Thr concentration used in the present study.

In summary, data of fattening performance did not fit regression equations usually used for derivation of amino acid requirements very well and because of the increase of growth and feed to gain ratio up to the highest Thr concentration used there is neither a breakpoint nor a plateau detectable. On the other hand, because daily gains in treat 5 and 6 were significantly higher as compared to all other treatments, data of growth performance indicate an optimum Thr supply which was at least higher, than the dietary Thr concentration of 5.1 g/kg (corresponding to a Thr:Lys ratio of 0.61) given to animals of treat 4. Moreover, an increase of dietary Thr concentration from 5.3 g/kg (treat 5) to 5.7 g/kg (treat 6) reduced the time span of the fattening period about 4 days and improved feed to gain ratio by nearly 6 %. Even if not significant, these data indicate a Thr requirement of at least 5.7 g/kg (corresponding to a Thr:Lys ratio of 0.68) for an optimum feed to gain ratio. This result is in reasonable agreement with previous studies conducted with pigs of the given live weight range. SCHUTTE et al. (1997) reported that the maximum growth rate for 50 to 95 kg pigs was obtained at a Thr:Lys ratio of about 0.65 to 0.68 and derivation of requirements using feed to gain ratio as a response criterion gave the same results. Similarly, SALDANA et al. (1994) obtained an optimum Thr:Lys ratio of about 0.67 for maximum gain/feed using a quadratic model for requirement determination. USRY (2000) suggested a slightly higher Thr:Lys ratio of 0.70 for optimum performance of pigs in the late finisher stage (90–118 kg body weight).

In contrast to these data, BOISEN et al. (1997) concluded from a literature review that the optimum Thr:Lys ratio for finishing pigs is 0.64 and therefore considerably lower than derived from data of the present study or suggested by the authors mentioned above. PEDERSEN et al. (2003) obtained comparable low Thr:Lys ratios of 0.64 by using daily weight gain, feed/gain, carcass characteristics and the plasma urea concentration as response criteria. However, pigs used in this study had lower body weights than the pigs used in our study and therefore, the reason for different requirement estimations may be associated with a different final weight in the studies. Furthermore, the study was conducted using pigs with daily weight gains from 788 to 803 g at a daily energy intake comparable to our study. Given that the pigs in the present study had average daily gains of at least 885 g at a suboptimal Thr supply and of 1046 g at the highest Thr level, the higher optimum Thr supply derived from the present study may be due to the extraordinary high performance level realized in the present study, what, in turn, may be related to genetics.

WECKE et al. (2006) derived an optimum dietary Thr:Lys ratio of about 0.60 and 0.65 for pigs in the live weight range of 70–80 and 90–115 kg, respectively, and those recommendations agree well with the wide optimum Thr:Lys ratio of 0.60 for pigs with a body weight above 40 kg given by the DLG (2002). Nevertheless, the study of WECKE et al. (2006) was a N-balance study and was conducted to evaluate the variability of the efficiency of Thr in different feed proteins for growing pigs. Thus, the reason for the lower requirement estimations can be explained by the use of a different methodological approach.

4.2 Carcass characteristics

In opposite to data of BARTELT et al. (2004), which indicate a tendency of lean meat percentage to increase and of back fat depth to decrease with an increasing Thr:Lys ratio, in the present study no effects of an increasing Thr:Lys ratio on carcass characteristics were observed. Neither the carcass composition (Table 5) nor the parameters of the meat quality traits (Table 6) were affected by different Thr levels in the diet and similar observations were made by other authors. For example, Schutte et al. (1997) reported that backfat thickness, lean meat percentage and muscle thickness were not affected by an increased Thr content of the diet. Similarly, PEDERSEN et al. (2003) observed that neither an increasing Thr level nor a different daily energy intake (30 or 40 ME MJ/d, respectively) significantly affected carcass characteristics in finishing pigs fed a 16.1 % CP diet. Also, in an experiment of ETTLE et al. (2004) there was no influence of dietary Thr level on different carcass characteristics of finishing pigs fed diets with a CP concentration of about 14.8 %. Given that daily gains were clearly increased at maximum dietary Thr concentrations in the present study, those data indicate that the influence of Thr supply on carcass characteristics is much lower than the influence on growth performance. On the contrary, a dietary restriction in other amino acids, such as lysine (CLINE et al., 2000) seem to have a considerably higher impact on carcass characteristics than observed for Thr in the present study. These observations support the assumption that dietary Lys is more important for lean meat deposition than dietary Thr, but that Thr is highly involved in functions related to maintenance requirement, e.g. gut mucin production or immunoglobulin synthesis (HAN and LEE, 2000).

4.3 Urea concentration in the blood plasma

Besides growth performance and carcass characteristics, plasma urea concentration was used in the present study to determine the optimum dietary Thr supply in finishing pigs. KOHN et al. (2005) recently reviewed the results from 41 research publications and confirmed that the blood urea nitrogen concentration can be used to quantify nitrogen utilization and excretion in various animal species. An increasing amino acid utilization decreases urea synthesis and, thus, decreases plasma urea nitrogen concentrations. Therefore plasma urea concentrations are expected to be minimized at an adequate amino acid supply (COMA et al., 1995) and may therefore serve as a useful tool to estimate the optimum dietary Thr supply. Nevertheless, data of TAYLOR et al. (1982) indicate that the optimum dietary Thr supply derived from plasma urea concentration is lower, than the requirement derived from growth data. Moreover, data of PEDERSEN et al. (2003) indicate a quadratic response of plasma urea concentration due to an increasing dietary Thr supply.

In the present experiment, an increase of the dietary Thr concentration from 4.4 to 4.7 g/kg lead to a reduction of plasma urea concentration from 4.4 to 3.6 mmol/l, respectively, a level, at which plasma urea concentration was not influenced by a further increase of Thr supply (Table 3). Thus, derivation of optimum Thr supply using an asymptotic model and plasma urea concentration as a response criterion indicate a Thr requirement for finishing pigs of about 4.8 g/kg diet (R^2 = 0.95), and therefore a considerable lower requirement, than derived from data of fattening performance. On the other hand, plasma urea concentration remained rather constant over the wide dietary Thr supply of 4.7 to 5.7 g/kg. A surplus of dietary Thr is expected to result in higher plasma urea concentrations than observed at an adequate Thr supply. The reason for this is the inability of the organism to utilize single amino acids given in excess relative to other amino acids. Therefore, interpretation of data of plasma urea concentration of treat 6 suggest that Thr was not given in excess of the actual needs and Thr requirements were probably as high as derived from data of feed to gain ratio.

5 Conclusion

Based on daily gain, the optimum dietary Thr:Lys ratio is suggested to be at least 0.65 g/g. Given that length of fattening period was minimized at the highest Thr level used in the present study, and that a increase of Thr:Lys ratio from 0.65 to 0.68 increased feed to gain ratio numerically by 6 %, it is concluded that a Thr:Lys ratio of at least 0.68 is required to optimize both growth and feed to gain ratio. Because it was not possible to derive the Thr requirement by regression approaches, further studies are required to approve the high Thr requirement derived under the present feeding conditions and performance level. Derivation of optimum Thr:Lys ratio by the use of plasma urea concentration as a response criterion did not correspond to data of growth performance or feed to gain ratio. Therefore, further studies should also verify the validity of plasma urea concentration as a criterion for derivation of Thr requirements in pigs. Even at a low dietary CP concentration of 13.4 %, carcasses with an exceptionally high quality can be produced. Influences of dietary Thr concentration on carcass quality are negligible.

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