Amino acid nutrition in ducks

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Summary

The world duck meat production is still increasing which emphasizes the need for knowledge about nutrient requirement for feed formulations allowing best possible meat production. Differences in the anatomy, physiology and metabolism between land-birds and waterfowl and even within water-fowls causes that no data from research with broilers can be used for formulating duck diets. Recent research found the current recommendations of 1.16 % lysine, 0.42 % methionine and 0.76 % methionine+cystine (Evonik, 2010) as close to the requirement of ducks from hatch to 14 days of age. Ducks from 15-35 days of age seems to require more than 0.54 or 0.84 % methionine or total sulfur amino acids, respectively, for body weight gain which is higher than the currently recommended level. However, trials with finishing ducks of 36-49 days of age resulted in values of 0.35 and 0.59 % which is lower than assumed before and confirmed findings of a more moderate growth performance in ducks from 35 days on. In conclusion a deeper knowledge to the amino acid requirement of Pekin ducks and additionally the investigation of digestibility coefficients could lead to improved duck meat production.

Keywords: duck, amino acids, nutrition

Introduction

Like the meat production of all poultry species the world duck meat production is still increasing. In 2009 3.8 million tons of duck meat were produced, this is about 1 million more than 2000 (WattAgNet.com, 2011). The core market for duck meat is still Asia with 84% of the world production. Although the duck meat production is close to the turkey meat production in relation to the world poultry meat market, the knowledge about nutrient requirement and digestibility of feedstuffs is poorer for the waterfowl than for the big American land bird. This difference in knowledge is emphasized by comparing the background for the amino acid recommendations. The recommendations for crude protein and amino acid supply of the NRC (1994), for instance, are for 38% backed by research in turkey but just for 20% in duck. The current paper will give an overview to the current knowledge in amino acid nutrition of ducks and will discover the lacks.

Differences between poultry species

The anatomical, physiological and metabolic differences in digestion tract between poultry species was observed by some researchers. The small intestine was found to be of lower weight compared to metabolic body weight in ducks than in broilers (Jamroz *et al.*, 2001, 2002a and 2004; Borin *et al.*, 2006), but higher in ducks than in turkeys (Applegate *et al.*, 2005).

A very interesting research was conducted in line with a doctoral thesis at the University of Halle-Wittenberg and the Federal Agricultural Research Center Braunschweig-Völkenrode, Germany (Wiederhold, 1996). The thesis determined the body composition of Pekin ducks, Muscovy ducks, crossbred Mulards and geese with the non-invasive magnet resonance tomography (MRT) and found significant differences between the strains as well as between the sexes among a strain. The birds were compared at about 4, 6, 8 and 10 weeks of age and the parameters live weight and volume of breast muscle, thigh muscle and abdominal fat pad were determined. The duck strains were close together and below the geese for all parameters, but within the duck strains a more consistent growth was observed for the Pekin ducks and the Mulards than for the Muscovy ducks in which the growth performance and body composition between the sexes showed the biggest difference of all tested birds. Although the Pekin ducks started with a higher weight than the mulards, both strains ended up at the same weight. However, the part of valuable breast and thigh muscle was higher in the mulards.

The above described investigations proved differences in the development of muscle and organ growth not only between species, but also between strains within the species duck leading to the assumption of differences in physiological functions and metabolism.

Amino acid digestibility

The differences in intestinal tract and growth suggested differences in the digestibilities of nutrients. A comparison of the apparent ileal digestibility of amino acids (Jamroz *et al*., 2001) showed in average 76, 69, and 56% for chickens, ducks and geese, respectively. The digestibilities of methionine (Met) and lysine (Lys) were 70 and 72, 44 and 57, 52 and 41 % for chicken, ducks and geese, respectively. Conclusively, the amino acid digestibility in both waterfowl species is significantly lower than in the tested land-fowl. However, even within the waterfowl species a difference for single amino acids was detected without a special direction. A second comparison of the same researcher group (Jamroz *et al*., 2002b) resulted in amino acid digestibilities of 72, 55, and 63 % in chicken, ducks and geese, respectively. The digestibility of Met and Lys was found with 74 and 62, 55 and 41, 60 and 41 %. These results showed again the higher apparent amino acid digestibility in the land bird than in water birds, but the difference within the water birds had another direction with generally higher values in geese than in ducks. Kluth and Rodehutscord (2006) assessed the standardized ileal digestibility (SID) of amino acids in 3 week old broiler chickens, turkeys and Pekin ducks by multiple linear regression analysis established by Rodehutscord (2004). The basal diet was based on corn and wheat gluten and the investigated ingredients soybean meal or rapeseed meal, respectively, were added in the expense of corn starch. The results showed a lower digestibility in ducks than in chicken and turkey in the mean of all amino acids, for Met and Lys the digestibility was even significantly ($p<0.05$) lower for ducks in both tested raw materials. So, the assumption of lower amino acid digestibility in waterfowl than in land-fowl was confirmed by this study for the meals of soybean and rapeseed. The impact of single ingredients on the amino acid digestibility in waterfowl is also obvious.

To achieve the true or standardized ileal amino acid digestibility, the inevitable or endogenous loss has to be subtracted from the apparent ileal digestible amino acids (Lemme *et al*., 2004). The endogenous loss is known to be influenced in broilers by age (Ravindran and Hendricks, 2004) and diet composition (Kluth *et al*., 2009; Ravindran *et al*., 2009). To prove this impact in ducks, Akinde *et al*. (2010) studied the inevitable loss of nitrogen in Pekin ducks in a two-factorial design with two levels of crude fiber and five levels of crude protein in three-week old ducks and three levels in 16 week old ducks. The results showed that the inevitable losses of nitrogen and, by extension, the maintenance protein requirements were not influenced by dietary crude fiber but varied with body weight or age in the white Pekin duck when expressed in relation to body weight. This is in line with findings in broilers.

As explained above, digestibility coefficients are significantly different between ducks and broilers. Hence, coefficients determined in broiler cannot be applied for ducks. Values for amino acid digestibility of feedstuffs in ducks are as scarce as the knowledge to the requirement for digestible amino acids, thus recommendations for the amino acid supplementation of duck diets are usually given as total amino acids.

Genetic improvement of modern Pekin ducks

An additional inevitable aspect is the genetic improvement of modern ducks. According to Pingel *et al*., the final market weight of a Pekin duck in 1969 was 2400 g at 56 days of age with a breast muscle yield of 9 %. Thirty years later Pekin ducks grew up to 3820 g within a 49-day growing period with a breast muscle yield of 16.6 % (Timmler and Jeroch, 1999). This rapid progress in growth performance and protein deposition premises the knowledge of the amino acid requirement of this modern waterfowl.

Amino acid requirement of ducks

Summarizing the above introduced studies to the differences in the anatomy, physiology and digestibility of some nutrients between the waterfowl duck and the land-bird chicken emphasized that recommendations for the amino acid supplementation of duck diets cannot be taken from research conducted with broiler. Additionally, the consideration of the strain used in the study seems to be reasonable, but the scarcity of research in ducks gives no chance for recommendations provided per strain. As a first step to produce duck diets with amino acid contents close to the requirement either for maintenance or for maximum growth, the existing studies should be summarized and the mean values of this summary should be taken as the currently best possible approach.

Hou (2007) summarized research to the need for amino acid of ducks and found results in Pekin and Muscovy ducks and some regional grown Chinese duck strains as well as in crossbreds of these strains and of different age ranges. As the main strain for the production of duck meat is the Pekin duck, recommendations are usually referring to this strain. **Table 1** shows the suggested total amino acid contents of the NRC (1994), Hou (2007) and Evonik (2010). Due to research results Hou distinguished the second part of growing into a grower and a finisher phase. This is meaningful having the development of the intestinal tract in mind. However, the background for the single phase is even scarcer. Over the time an increase of the recommended supplementation level for the sulfur amino acids and Lys is recognizable. Recommendations for the other amino acids are close together. The small differences in tryptophan, arginine and valine can be explained by the small number of research conducted to these topics after the publication of the NRC recommendations.

For the sulfur amino acids, Lys, threonine (Thr) and tryptophan (Trp) more recent data are available. The doctoral thesis of Bons (2000) revealed by conducting dose-response trials higher needs for methionine+cystine (M+C), Lys and Thr to achieve maximum growth of the modern Pekin duck for the age ranges of 1-21 and 21-49 days. By evaluating the data with an exponential regression levels of 1.16 and 1.03% Lys, 0.76 and >0.87% M+C, >0.99 and 0.98% Thr and 0.21 and 0.18 % Trp were found to perform optimum body weight gain and feed conversion ratio from 1-21 days, respectively. For the age range from 21-49 days the levels 0.83 and 0.73% Lys, 0.73 and >0.84% M+C, 0.62 and 0.62% Thr and 0.23 and 0.27% Trp were found as optimal for body weight gain and feed conversion ratio, respectively. Additionally optima for breast meat yield were found to be 0.90% Lys, 0.77 % M+C, 0.66% Thr, and >0.28% Trp.

Xie *et al*., (2009) investigated the Lys requirement of male white Pekin ducks from 7-21 days of age. A recalculation of their data with exponential regression resulted in optima of 0.97% for body weight gain, 1.08% for feed conversion ratio, 1.39% for breast meat weight and 1.53% for breast meat yield.

To investigate the requirement for Met and M+C a dose-response trial was conducted by Evonik and Prof. Hou from the Chinese Academy of Agricultural Science in Beijing. A number of 1680 one-day old Pekin ducklings were housed in raised wire floor pens. During starter phase (1-14 days

Table 1 - Comparison of recommendations for the amino acid supply of Pekin ducks.

Reference	NRC (1994)		Hou (2007)			Evonik (2010)	
Amino acid	**0-2 weeks**	**2-7 weeks**	**1-14 days**	**15-35 days**	**36-49 days**	**1-21 days**	**22-49 days**
Lysine	0.90	0.65	1.10	0.85	0.65	1.16	0.90
Methionine	0.40	0.30	0.50	0.40	0.30	0.42	0.42
M+C	0.70	0.55	0.82	0.70	0.60	0.76	0.77
Threonine	-	-	0.75	0.60	0.45	0.84	0.66
Tryptophan	0.23	0.17	0.23	0.16	0.16	0.21	0.20
Arginine	1.00	0.89	-	-	-	0.94	0.76
Isoleucine	0.50	0.44	-	-	-	-	-
Leucine	1.50	1.33	-	-	-	-	-
Valine	0.80	0.71	-	-	-	0.77	0.59
Histidine	-	-	-	-	-	0.42	0.32
ME, MJ/kg	11.70	12.12	-	-	-	12.20	12.60
kcal/kg	2796	2897	-	-	-	2940	3000

M+C = methionine+cystine, ME = metabolizable energy.

Table 2 - Diet composition and analyzed nutrients of basal diets used in a dose-response trial with Pekin ducks during three feeding phases.

Phase, day	1-14	15-35	36-49	Phase	1-14	15-35	36-49
Diet and energy composition:				**Analyzed nutrients:**			
Corn	55.34	63.52	78.96	Crude protein	22.97	18.85	14.16
Peanut meal	34.69	10.06	15.0	Lysine, %	1.20	1.06	0.66
Dicalcium phosphate 22	1.50	1.50	1.30	Methionine, %	0.28	0.27	0.21
Soybean meal, 44%CP	2.13	18.57	-	Cystine, %	0.31	0.28	0.23
Soybean oil	2.60	3.00	1.87	M+C, %	0.59	0.55	0.44
Premix	1.00	1.00	1.00	Threonine, %	0.89	0.77	0.54
CaCO3	1.21	1.25	1.10	Tryptophan*, %	0.23	0.24	0.16
Na-Bicarbonate	0.37	0.25	0.10	Arginine, %	2.09	1.25	1.130
NaCl	0.08	0.18	0.24	Isoleucine, %	0.72	0.66	0.45
Lys-HCl	0.73	0.43	0.33	Leucine, %	1.61	1.47	1.16
L-Threonine	0.32	0.20	0.15	Valine, %	0.90	0.79	0.59
L-Tryptophan	0.03	0.04	0.04	Histidine, %	0.51	0.44	0.36
Total	100	100	100	Phenylalanine, %	1.05	0.85	0.64
ME, kcal	2,940	3,011	3,205	Glycine, %	1.11	0.75	0.66
ME, MJ	12.30	12.60	13.41				

of age) 10 birds per pen served the experimental unit while for the grower and finisher phase (15-35 and 36-49 days of age, respectively) 8 birds per pen served as one of the eight replicates. All birds received commercial feed until start of the individual experimental feeding. Nine levels of methionine were tested in corn-peanut meal based diets providing all other amino acids 10% above recommendation of Evonik (2010) during the starter and grower phase. Energy and crude protein levels were orientated according to the suggestions of Prof. Hou. The deficient Met and M+C levels in starter and grower phase were 0.28 and 0.27% as well as 0.59 and 0.55%, respectively. These levels were lifted up in eight increments each of 0.04%. The amino acid analysis confirmed the diet composition except for treatment 7 of the starter phase which showed a lower lysine content causing a drop in growth performance and for treatment 9 of the grower phase where an unexplainable high crude protein content was analyzed which although without direct influence on growth parameters was excluded in the assessment.

As during a first attempt of investigating the finisher phase no response could be measured, it was concluded that with 0.257 and 0.538% in the basal diet the Met and M+C levels were still above the requirement. Prof. Hou also assumed the Lys content and following this the whole amino acid profile as too high. Thus, the phase was repeated with amino acid contents lowered to levels based on his experience. The outstanding object of this basal diet was the low Lys (0.66%) and crude protein (14.16%) content. In five steps of 0.04% the level of Met and M+C was incremented from 0.200 and 0.420% to 0.400 and 0.620%, respectively.

The response during the starter phase showed significant differences ($p<0.05$) for body weight gain and this parameter allowed for exponential regression (**Figure 1**) and resulted in an optimum level of 0.42% Met and 0.75% M+C. For the grower phase the exponential regression was not only possible for body weight gain (**Figure 2**) but also for breast meat yield. The optima were computed to be close (breast meat yield with 0.53% Met) or higher (body weight gain and breast meat yield for M+C) than the highest tested level of 0.54% Met and 0.84% M+C. Results of the finisher phase showed also a significant development and the exponential regression ended up in optimal levels of 0.35% Met and 0.59% M+C for body weight gain (**Figure 3**). The feed conversion ratio allowed also for exponential regression resulting in 0.34% Met and 0.58% M+C.

These findings suggested Met and M+C levels higher than the current NRC (1994) but close to Evonik (2010) recommendation for the starter and

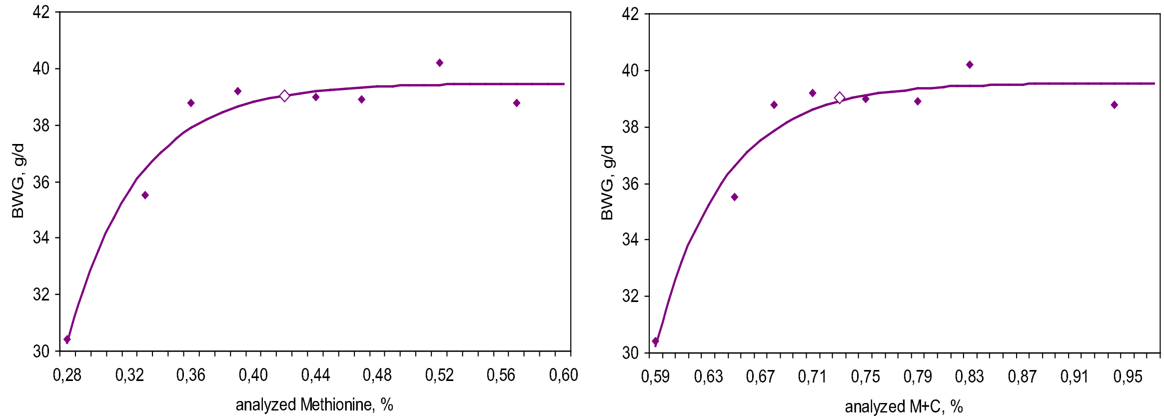

Figure 1 - Exponential regression to evaluate the optimum level of methionine (Met) and methionine+cystine (M+C) during the starter phase (1-14 days of age) of Pekin ducks; dark dots show trial results, white dot shows calculated optimum.

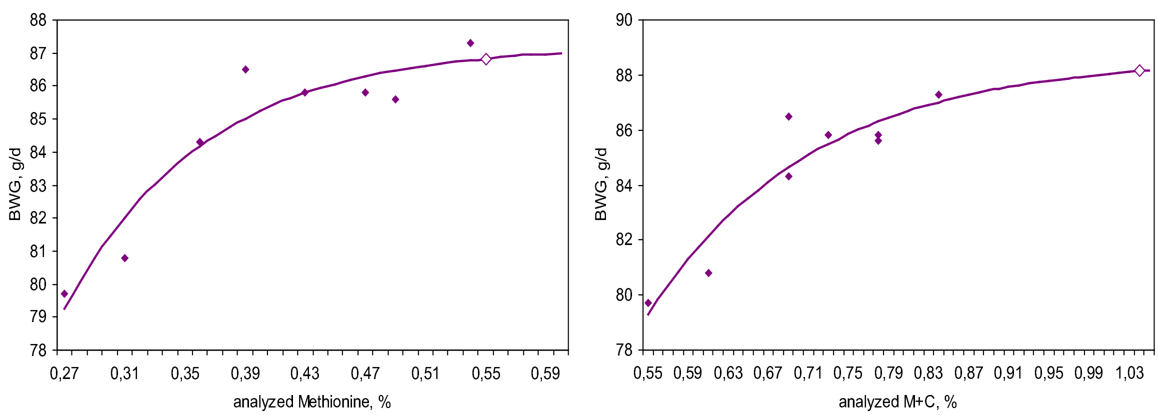

Figure 2 -Exponential regression to evaluate the optimum level of methionine (Met) and methionine+cystine (M+C) during the grower phase (15-35 days of age) of Pekin ducks; dark dots show trial results, white dot shows calculated optimum.

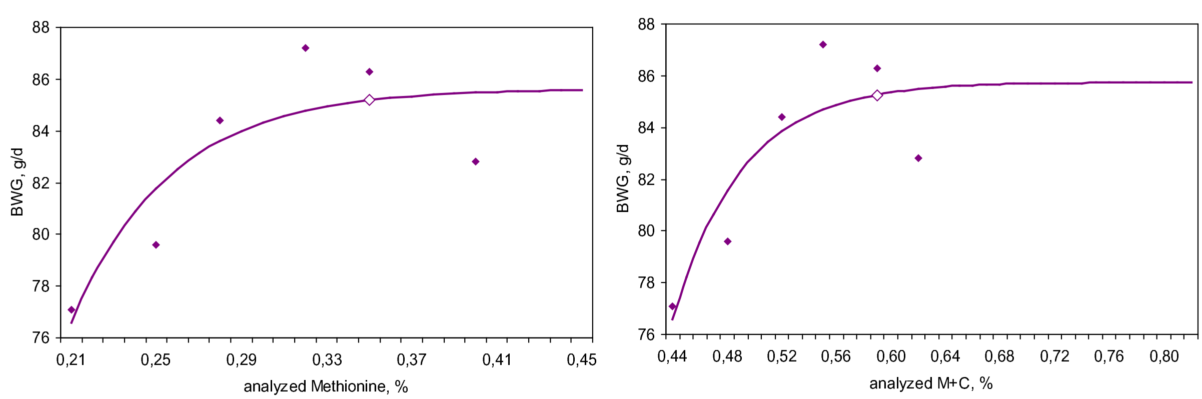

Figure 3 -Exponential regression to evaluate the optimum level of methionine (Met) and methionine+cystine (M+C) during the finisher phase (36-49 days of age) of Pekin ducks; dark dots show trial results, white dot shows calculated optimum.

Ariane Helmbrecht

grower phase. Only the finishing phase of the duck meat productions indicated adjustements for the sulfur amino acids which are lower than thought before for the maximum growth and being close to the recommendations of the NRC (1994).

It can be concluded that the fast muscle growth is finalized around day 35, and during the finisher phase ducks grow just moderate and the requirement for amino acids is therefore lowered. The doctoral thesis of Wiederhold (1996) also found a moderate increase of body weight, breast and thigh muscle for this phase but an ongoing increase of abdominal fat.

Supplemented amino acids

An additional conclusion of the above described trial is the possibility of using low crude protein diets in finishing Pekin ducks. Baeza and Leclercq (1998) tested low crude protein diets and balanced the first four limiting amino acids by adding L-Lysine HCl, DL-Methionine, L-Threonine and L-Tryptophan. The results showed no significant modification in growth or carcass quality when the crude protein level was greater than 12.4% in diets supplemented with the four essential amino acids.

Other authors assume a positive effect of using supplemented amino acids. Wu *et al.*, (2011) hypothesized that L-arginine might regulate body fat deposition in ducks from 21 to 42 days of age without affecting their fast growth rate. The results indicated that a diet with 1.00% supplemental L-arginine could reduce the fat deposition of carcass and abdominal adipose cell size (diameter and volume), enhance intramuscular fat in breast muscles, as well as increase muscle and protein gain.

Lack of knowledge

Considering the above described findings there is still a lack of knowledge for the best partition of the feeding phases for ducks older than 14 days. The knowledge of the requirement of the starting duck seems to be close to the requirement for maximum growth, but for grower and finisher phases the need for research is still given.

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