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Ammonia emissions: Abatement costs for feeding of fattening pigs

Following the publications of ammonia abatement costs for measures in the storage and application of liquid manure [1, 2], the abatement costs for different crude protein-adapted feeding systems of fattening pigs are presented in the present paper. The calculations of abatement costs were based on calculated nitrogen excretion and emission factors. The strongest reduction of N excretion and ammonia emission is already achieved with a two-phase diet. A further increase in the number of phases leads to only relatively small further reductions. The higher investment costs for the multi-phase feeding technique and the higher amino acid supplementation are compensated by saving expensive protein components. Depending on reference feeding system, farm size and average growth performance of the animals negative abatement costs from -2.92 to -16.14 €/kg NH_3 incur. Given the current costs of feeding technique and feeds, the NH_3 reduction through crude protein-adapted multi-phase feeding is economical.

Keywords

Ammonia emissions, abatement costs, crude protein-adapted feeding, pig fattening

Abstract

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There exist a variety of measures for the abatement of ammonia (NH_3) emissions. A crude protein (XP) adapted diet constitutes an efficient and cost-effective abatement measure in pig fattening. The reduced XP intake results in a linear decrease of nitrogen (N) excretion and NH_3 emissions [3, 4]. The magnitude of cost reduction depends, however, on the amount of amino acid supplementation and on current market prices of feed components.

Feeding systems

The feeding system applied in pig fattening can vary considerably. Therefore, the developed calculation methodology [1] was only applied to some selected feeding systems. A single-phase feeding system with a conventional diet (reference 1) and a single-phase feeding system with a XP-adapted diet respectively (reference 2) were defined as reference systems. Compared to single-phase feeding, multiple-phase feeding systems are gaining importance in Germany, and for newly constructed stables they constitute the state of the art. Different multi-phase feeding systems with XP-adapted diets were therefore considered for the calculations (**Table 1**).

All considered diets are based on different ratios of wheat, barley, HP soybean meal extracts and soybean oil. To ensure a sufficient supply of essential amino acids in a XP-adapted diet, mineral feeds with high amino acid supplementation are used

Table 1

Investigated multi-phase diet systems

	Phase	2-Phasenfütterung *Two-phase feeding*	3-Phasenfütterung *Three-phase feeding*	Multiphasenfütterung *Multiple-phase feeding*
Lebendgewicht *Liveweight* [kg]	Phase 1 Phase 2 Phase 3	30–70 70–118 -	30–50 50–90 90–118	10-kg-Schritte *10 kg steps*
Rohproteingehalt *Crude protein* [%]	Phase 1 Phase 2 Phase 3	17,5 15 -	17,5 16 15	17,5–14

in practice. For the calculations, the following supplementation of amino acids was assumed: 6 % lysine and 1.5 % methionine for the single-phase feeding with conventional diet, for all other feeding systems 10 % lysine, 1.5 % methionine and 2 % threonine.

Calculations were performed for fattening farms with 517, 960 and 1 920 animal places according to KTBL standard BAUKOST version 2.7 (2010), assuming houses with forced ventilation and fully slatted floor. The emission factor for this type of housing is 30 % of the total ammoniacal nitrogen (TAN) [5]. The growth curve as well as the energy and XP requirements were estimated based on algorithms of the German Society of Nutrition Physiology (Gesellschaft für Ernährungsphysiologie) [6]. A nitrogen flow model was developed to calculate the N retention, total N excretion as well as urinary and fecal N excretions. The influence of the average growth rate of pigs on N excretion, NH_3 emissions and abatement costs was investigated.

Nitrogen excretion and ammonia emissions

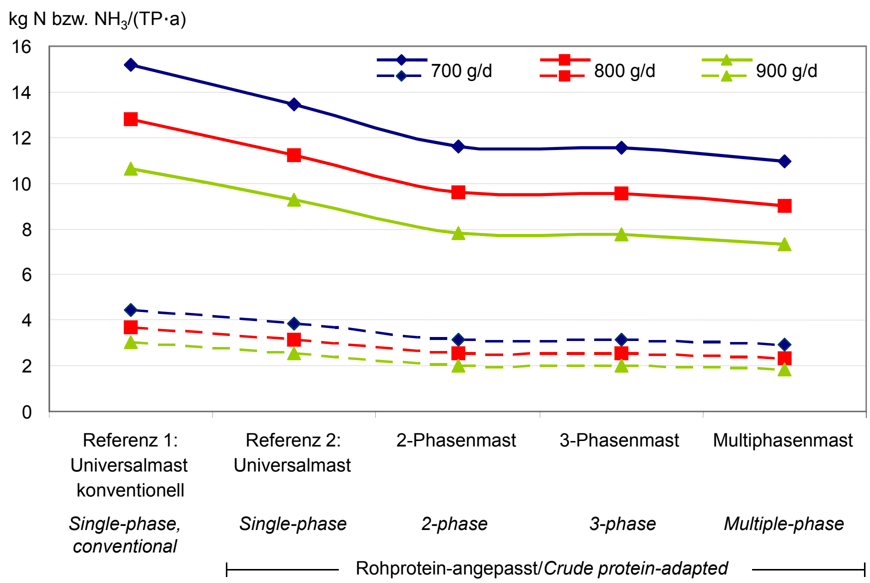
A clear reduction of N excretion and consequently of NH_3 emissions is already realized through a division of the fattening period in two phases in combination with a reduction of the XP content in the diet. By contrast, a further increase in the number of fattening phases has only a small additional effect (**Figure 1**). This can be explained by the fact that the assumed XP content of the diets in the first and last phase of the two- and three-phase feeding system respectively was the same. The highest reduction of excretion and emissions is realized through the multiple-phase feeding system. By reducing the XP content to 14 % in a higher number of phases, the N excretion are reduced by approximately 30 % (compared to reference 1) and 20 % (compared to reference 2). Multi-phase feeding does not only result in a reduction of total N excretion, but also reduces the fraction of urea N. The fraction of urea N decreases from 80 % in the single-phase feeding system with conventional diet to 73 % in the multi-phase feeding systems. Urea is rapidly converted to ammonium and further to ammonia and therefore is the main contributor to ammonia emissions. Consequently, the calculated relative emission abatements through multi-phase feeding (35 and 26 % respectively) are higher than the calculated relative reduction of N excretion.

The amount and composition of the N excretion and thus the amount of NH_3 emissions are not only dependent on the XP content and XP digestibility of the feed, but also on the average growth rate of pigs. The higher the growth rate of pigs, the more of the ingested XP is retained and the lower the rate of the unmetabolized XP. Thus, the N excretion of pigs with an average daily growth rate of 700 g were calculated at 10.9 and 15.2 kg/(AP · a) for the XP-adapted multiple-phase feeding system and for the conventional single-phase feeding system, respectively. By contrast, pigs with an average daily growth rate of 800 g and 900 g only excrete 9 to 12.8 kg N/(AP · a) and 7.3 to 10.6 kg N/(AP · a), respectively. Correspondingly, the NH_3 emissions decrease with an increasing growth rate (**Figure 1**).

Feeding and abatement costs

Due to the more sophisticated feeding technique the fixed costs are higher for the multi-phase feeding systems as compared to the single-phase feeding systems. With an increasing number of animal places, the fixed costs per animal place are decreasing. They are lowest for the conventional single-phase feeding system with 1 920 animal places (3.35 €/(AP · a)) and highest for the multiple-phase feeding system with 517 animal places (9.59 €/(AP · a)). However, fixed costs only represent approximately 2.5–9.5% of the feeding costs, whereas variable costs,

Fig. 1



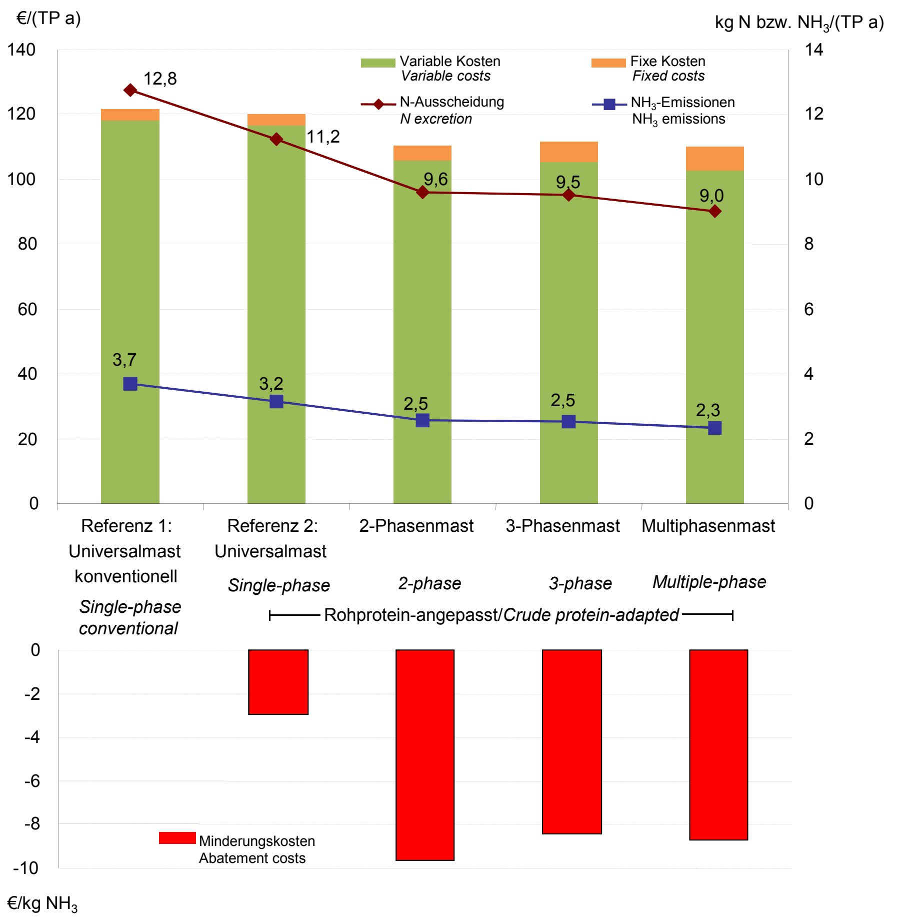
N excretions (upper lines) and NH_3 emissions (lower lines) of investigated feeding systems particularly feed costs are the major cost component. By reducing the XP content of the feed, cost-intensive protein components are saved and feed costs decrease. In addition, the pigs' water requirements and consequently the costs for drinking water decrease. Thus, the higher fixed costs arising for the feeding technique are (more than) compensated through the decreasing variable costs. This effect is even more pronounced for pigs with a higher average growth rate. Due to a better metabolization of the XP, their feed requirements are lower and consequently feed costs further decrease. The variable costs for pigs with an average daily growth rate of 700 g amount to 117–135 €/(AP · a), while they decrease to 92–105 €/(AP · a) for pigs with 900 g daily growth rate.

The lower costs of the multi-phase feeding system in combination with the realized abatement of NH_3 emissions result in negative abatement costs thus cost savings. Costs, N excretion rates and NH_3 emissions for a farm with 960 AP and pigs with an average daily growth rate of 800 g are presented in **Figure 2**. A two-phase feeding system with XP-adapted diet seems particularly interesting for smaller farms, since the technical and organizational requirements as well as feeding costs are manageable, though depending on the implementation concept. In combination with a strong decrease in N excretion and NH_3 emission rates, the two-phase feeding system results in cost savings of 9.42 to 9.66 €/kg NH_3 (in comparison to reference 1) and 13.15 to 13.55 €/kg NH_3 (in comparison to reference 2). For larger farms, by contrast, a multiple-phase feeding system tends to be more appropriate due to the cost degression and higher automatization and precision of the feeding. The cost savings of the multiple-phase feeding system on a farm with 1 920 AP amount to 9.41€/kg NH_3 (in comparison to reference 1) and 12.46 €/kg NH_3 (in comparison to reference 2), respectively. The higher cost savings in comparison to reference 2 result purely arithmetically from the smaller emission abatement.

Conclusions

With the assumptions made with regard to the XP content of the feed and the change between fattening phases, the most pronounced abatement of ammonia emissions is possible through a shift from a single-phase to a two-phase feeding system. A further increase in the number of phases merely has an additional effect. Decreasing feed costs more than compensate the high fixed costs for the feeding technique. Therefore, no costs arise from the implementation of multi-phase feeding systems with XP-adapted diet for the abatement of ammonia emissions.

Fig. 2



Costs, N excretion and NH_3 emissions (960 animal places, 800 g daily weight gain)

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