Advances in Sow Nutrition-
The Use of Mathematical Modelling in Sow Nutrition
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ABSTRACT
Mathematical modelling can be used to describe and understand metabolic processes in sows which can lead to improvement in optimized performance and feeding. A model was developed to describe the milk yield and composition of sows during lactation where litter size and gain was used as inputs to the model. The model can also be used within a whole-animal model to describe the protein metabolism of the sow, particularly secretion in milk. In order to simulate a group of sows in a more realistic way, information about the variation between sows was included in the model. The model can be used to develop new feeding strategies or optimize production.

BACKGROUND
The modern high producing sow has undergone major changes in the last few decades. Sows have become leaner and larger because of selection for lean meat and litter size has also increased. These changes emphasize the need of studying the metabolism and nutrient requirements of the modern sow in order to optimize her performance (litter size and growth) and longevity. Measurements of body composition and milk production for instance can be very labour intensive and expensive to carry out, and is therefore not done very often. Mathematical models can be a very effective tool to describe and generalize metabolic processes. An important aspect to consider when developing models is that the data should be relevant to the current production system as genetics of sows are changing rapidly. Therefore it is important to generate appropriate data when new or improved animals are used in the field. It is also important to test the model for its suitability to a given simulated group. Significant differences in prediction will occur if used on different breeds or parities of sows.

LACTATION CURVE MODEL
During lactation the sow requires energy and nutrients for maintenance and milk production. At this stage, the majority of the requirement is for milk production. To maximize milk production and avoid excessive weight loss during lactation it is important to determine the sow’s requirement at the different stages of lactation as accurately as possible. The major determinants of milk production are litter size (LS) and piglet growth (LG).

Hansen et al. (2012a) developed a mathematical model to generate lactation curves for sows. Litter size and average daily LG (kg/d) were used as inputs to the model. Figure 1 shows expected milk yield for three scenarios with varying LS and LG. As LS and LG change, so does the shape of the curve, indicating that milk production is not constant.

The model can also be used to estimate protein, lactose, fat and energy output in the milk. Figure 2a shows how the contents of fat, protein and lactose (%) change during lactation, and how this together with the milk yield (kg/d) curve can be used to estimate the daily output of
these nutrients in the milk (Figure 2b). Using this information the net energy output in the milk can also be calculated.

The model helps understand how LS and LG affect the milk yield of the sow, and also emphasizes that nutrient and energy requirements for milk productions changes throughout lactation. The mathematical model is described in detail by Hansen et al. (2012a).

![Figure 1. Plot of expected lactation curves for sows with litter size (LS) of 13, 11, and 13 and litter gain (LG) of 3.12, 2.31, and 2.73 kg/d, respectively. The arrows indicate time of maximum milk yield.](image)

**WHOLE ANIMAL MODELS**

The lactation curve model is an example of how a mathematical model can describe a certain process within the sow and such equations have also been developed to describe e.g. changes in body fat and protein, fetal growth, and maintenance requirements. All these equations can be put together in a whole animal model describing nutrient metabolism of a lactating sow.

Using a whole animal model, a group or herd of similar sows can be simulated by giving the inputs. In this type of model all sows in the given group will generate the same outputs (e.g. milk production).

An improvement of the model is to incorporate information about between-sow variation, because in reality a group of sows with same inputs (e.g. feed intake, BW and body composition) will not give the same outputs.

Hansen et al. (2012b) developed a whole animal model for lactating sows including between-sow variability for estimation of protein and lysine requirements. The requirement was calculated using a factorial approach. Information about between-sow variation on milk yield and composition, feed intake, composition of mobilized body fat and protein, energy and amino acids for maintenance and efficiencies of energy and amino acids for milk production and growth was included in the model. When simulating the protein requirement of 1000 similar sows the output is 1000 different curves (Figure 3), because of the inclusion of the between-sow variation.

From these curves the cumulative distribution function for protein requirement could be calculated for the entire lactation or for different stages.
In Figure 4 the cumulative distribution function for the protein requirement of each of the simulated sows is plotted and it shows the variation between sows. For example, if the sows are fed approximately 760 g of protein per day 50% of the sows will have their protein requirement met. In a production setting this means that any proportion of sows that will have their requirement met can be used and this could depend on for instance feed prices or other production factors. For example, if feed prices are high compared to the profit for a higher piglet growth, then a lower proportion of sows that meet the requirement could be chosen.

Figure 2. Plot of a) milk composition (%), and b) nutrient output (g/d), LS = 13, LG = 3.12.
There are several other models that can also simulate sow metabolism (e.g. Pettigrew et al., 1992, Dourmad et al., 2008), but these models do not take into account the between-sow variation, which is valuable information in the development of strategies to optimize feeding and performance of sows.

Figure 3. Simulated protein requirement of 1000 sows during lactation.

Figure 4. Cumulative distribution function for the protein requirements for 1000 simulated sows.
CONCLUSIONS

Mathematical models can help describe and get a better understanding of the metabolism of sows and by including the between-sow variation a group of sows is simulated in a more realistic way. The models can be used to determine nutrient requirements of different groups of sows, development of new feeding strategies and economic optimization of the production.

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REFERENCES


