Invited paper

REVIEW OF NUTRITION MODEL FOR GESTATION SOWS

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Abstract

Optimal feeding of sows is a complex problem due to their very different needs and use of nutrients during certain phases of the reproductive cycle. In pregnancy the sows need for nutrients is relatively small and slightly higher than maintenance requirements. In the last few years, the recommendations for feeding pregnant sows have been revised in such a way that greater protein (amino acid) and energy intake have been proposed for late gestation, compared to early gestation. The U.S. National Research Council (NRC, 2012) published the Nutrition models for swine, combined into a Microsoft Excel workbook and stored in the file NRC swine 2012. The program also includes a database with nutrient profiles of ingredients and a means to formulate diets and generate feeding programs. In the current paper, we will show agreements and differences between models and empirical data and discuss the implications and relevance for pregnant sow nutrition.

Key words: *needs, nutrition model, sows, recommendation*

Introduction

In pig production, sow nutrition is one of the most dynamic and most pre-stressed, so it is a challenge to meet the needs of nutrients and achieve satisfactory results. During exploitation, sow should produce about 70-75 piglets as is generally accepted. The key factors are: stage of gestation and feeding regimen, parity and anticipated litter size; and effects of housing and environmental conditions. These factors are main influence of nutrient requirements, and in the 2012 NRC model during evaluation different feeding programs they are indispensable. Pig farming is a process within which it is difficult to say ”This stage is the beginning of the process”. The question that arises is whether it is a second insemination or farrowing, or heat phase? But truly speaking it can be said that gestation is a phase of reproductive cycle which lasts more than 70% of the sow life. Also undisputable fact is that during pregnancy sows eat 2/3 of the total amount of feed consumed during the year. Therefore, as one of the measures for better efficiency Stančić et al. (2011) recommended early diagnosis of pregnancy, thereby reducing the number of unproductive feeding days per sow, significantly increasing the efficiency of utilization of accommodation space, and it is possible and appropriate timely intervention in each animal examined. With the ultrasound method, gestation can be diagnosed 17 days after insemination (Stančić et al., 2011). Over 95% of correct diagnosis is made by examination performed between the 25th and the 35th day of insemination. But significant deficiency, which significantly limits the large-scale use of this method in practical production is a high price of ultrasound equipment (Stančić et al., 2011). Reproductive problems, which may result in the reduction of sows productivity or early culling, are often related to extreme variations in body reserves (Dourmad et al., 1994; Kovčin et al. 2009), although body reserves should be considered more as an indicator of the risk rather than as the real cause of problems. During pregnancy, sufficient body reserves must be built to compensate for the eventual nutritional deficit that may occur in the following lactation. However, these reserves should not be excessive in order to avoid the occurrence of farrowing problems that are typical for fat sows, or to impair feed intake after farrowing (Dourmad et al., 2008). The sow nutrients requirements in the beginning of gestation are small, slightly higher than maintenance requirements, which are the largest in the structure, compared with growth (maternal protein and fat deposition), fetus, mammary tissue, uterus, and placenta and fluids. Therefore, regardless of the small requirements for protein and energy during gestation, and due to the aforementioned facts, the impact on reproductive efficiency and cost of production of this stage is huge and very important.

Protein and energy requirements

The values for complete feed for pregnant sows and gilts according to the feed quality regulative of the Republic of Serbia are shown in (Table 1).

Table 1. *Values for complete feed for pregnant sows and gilts according to the feed quality regulative of the Republic of Serbia (the Official Gazette of the Republic of Serbia, no. 4/2010)*

Protein, % min.	13
ME, MJ/kg, min.	12.0
Lysine, %, min.	0.55
Meth+cist, %, min.	0.3
DM, %, min	86.5
Cellulose, %, max	9
Ash, %, max.	8
Ca, %	0.75 – 1.00
P, % min.	0.55

The use of diets with 13% CP and 12 MJ ME, during the whole period of pregnancy without a detailed analysis of the individual requirements of each sow is believed to show a retrograde attitude. Kleisiary (2007) showed increased piglet birth weight when the dietary protein content was increased from 11 to 13% for the last 30 day of pregnancy. According to the NRC (1998, 2012) models of the requirements, they should be coordinated with body weight of sows during mating, growth during pregnancy, as well as the expected number of piglets per litter. Although the gestation as a sow life period has been characterized like period with low need in proteins and other nutrients, the quantity and quality of protein in this stage according to many researchers may have a significant impact on the reproductive efficiency and profitability of production. This is particularly pronounced in the last stage of pregnancy. Therefore it is important to define nutrition program of sows that will ensure maximum production of piglets with a minimum amount of protein and minimal cost of feed. INRA and NRC have some differences that largely define their specificity, for example NRC (2012) includes AA balances for calculating sow requirements, but the model does not include manure composition and mass calculations.

On the other hand the InraPorc model (Dourmad et al., 2008) estimates the requirements of gestating and lactating sows, but does not estimate nutrient excretion and emission.

Table 1 shows that the same diet could be used for gestation sows and gilts. This can cause a potential problem if gilts are kept in groups without automatic feeding. In such circumstances, the efficiency of the entire herd of sows may be reduced. Wholesale exclusion of young sows is the consequence of inadequate nutrition of growing gilts and gilts just before the mating. Many studies indicate that gilts extremely meaty breed body weight of 100 kg should be reached between 150-160 days and inseminated in the second or third estrus at the age of 220-230 days, the body weight of 130 kg and the back fat of 20 mm (Foxcroft 2002; Foxcroft et al., 2005; Jonson et al., 2009; Patterson et al., 2010). Gilts should continue to develop and to deposit the reserves necessary to meet the needs of the nutrients contained in milk (Kustina et al., 1999; Kovčin et al., 2006). Soto et al. (2011) observed increased piglet and litter weights when gilts were given an extra 1.82 kg/d during the last 2 weeks of pregnancy. Anyway increased exclusion of gilts after farrowing or sows after first and second farrowing is a huge problem, because it reduces the reproductive efficiency of the sow herd (Beuković and Kovčin, 1995; Beuković, 1999) .

Protein and amino acid balance

In the gestating sow model (NRC 2012) Pd (predicted total protein gain) predicted in the various protein pools is dependent on either time or energy intake and in products of conception is varied with anticipated litter size and mean piglet birth weight. Based on changes in Pd with stage of gestation and across parities, the gestating sow model clearly shows the need to increase feeding levels and daily AA (amino acid) intake towards the end of gestation in order to satisfy increased energy and AA requirements for products of conception and to avoid negative maternal energy and body protein balances. It also supports reductions in daily amino acid requirements with increasing parity (NRC 2012).

The weight of uterus increases during gestation (Walker and Young, 1992). Growth of the mammary gland is limited until 80 day of gestation (Figure 1), but the growth accelerates afterwards (Kim et al., 2009). Besides the growth associated with pregnancy, the sow will continue to grow toward mature weight. Fetal weight, fetal protein content and mammary protein content increase 5-, 18- and 27-fold, respectively, in the last 45 d of gestation (McPherson et al., 2004; Ji et al., 2006; Moehn S. and Ball R. O. 2013).

Goodband et al. (2013) in their analysis made compare estimates for AA, the new model first subdivides protein deposition and retention during gestation into six tissue pools: fetus, placenta plus fluids, uterus, mammary tissue, time-dependent protein deposition, and energy-dependent protein deposition (Figure 1). The same authors have pointed out that models changes in the protein accretion of these tissues over time are based mainly on serial slaughter studies with gestating sows according to (McPherson et al., 2004; Ji et al., 2006).

Goodband et al. (2013) pointed that the greatest AA requirement throughout gestation is that of time-dependent protein deposition and energy-dependent protein deposition for weight gain (represented by the blue and yellow band, Figure 1) of the gilt or sow. The greatest fetal growth and mammary development are late gestation what can be clearly seen at (Figure 1). Because of the protein and AA demands the best opportunity for replenishing body protein reserves is in early gestation.

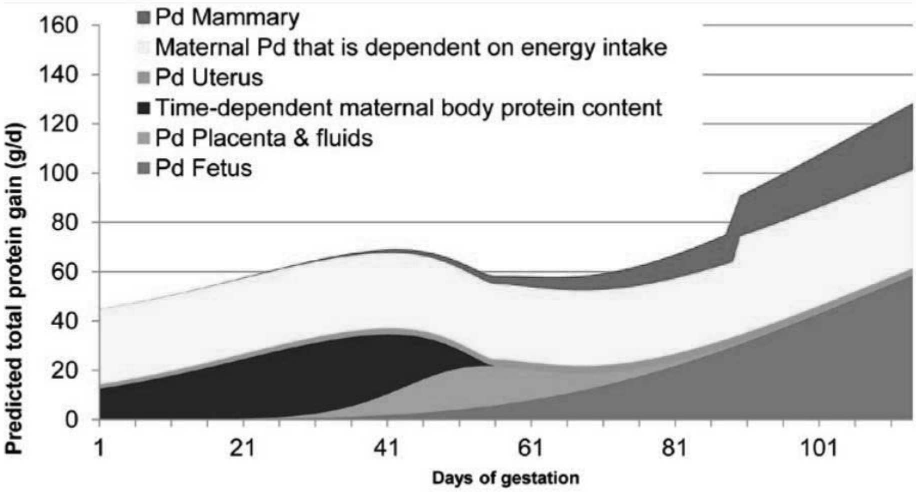

Figure 1. *Predicted total protein gain (Pd; g/d) in second-parity sows during gestation (Goodband et al. 2013)*

Analyzing the experimental data from Moehn S. and Ball R. (2013) research, group include the requirements in early and late gestation for lysine (Samuel et al., 2013), threonine (Levesque et al., 2011), isoleucine and tryptophan (Moehn et al., 2012a,b). In that analysis, each sow received each of six test diets in both early and late gestation. Feed allowance was kept constant throughout gestation. Amino acid requirements were determined using the indicator amino acid oxidation technique simultaneously with indirect calorimetry to measure energy expenditure. Key results of these experiments are compiled in Table 2.

Table 2. *Total lysine 1, threonine 2, tryptophan 3 and isoleucine 3 requirements of gestating sows (Moehn S. and Ball R., 2013)*

Amino acid	Phase	First parity (Srichana 2006)	Second parity (Samuel et al., 2010)	Third and forth parity (Levesque et al., 2011)
Lysine	EG	15.0	13.1	8.1
	LG	18.0	18.4	13.0
Threonine	EG	n/a	7.0	5.0
	LG	n/a	13.6	12.3
Tryptophan	EG	n/a	1.7	n/a
	LG	n/a	2.6	n/a
Isoleucine	EG	n/a	n/a	3.6
	LG	n/a	n/a	9.7

n/a – not available

Table 3. *Changes in sow performance during amino acid requirement studies in early (EG) and late gestation (LG) over 3 parities (Moehn S. and Ball R., 2013)*

Parity		BW, kg	Maternal gain, kg	ME intake, MJ/d	Protein retention, g/d	Energy retention, MJ/d	Litter size	Litter weight, kg
2	EG	177	44	34.2	32	3.0	13.8	19.5
2	LG	215		34.5	126	-0.7		
3	EG	205	40	36.1	38	1.2	13.6	20.1
3	LG	244		36.0	119	-0.9		
4	EG	240	25	35.6	4	1.5	15.8	22.1
4	LG	266		35.5	64	-1.3		

Table 3 shows body weight of sows increased from early to late gestation, regardless of parity, and increased from parity 2 to 4. Litter size and weight increased marginally over 3 parities. Protein deposition was greater in late than early gestation, across all parities, which is in accord with the fetal growth that occurs predominantly in late gestation. Thus, fetal growth drives amino acid requirements in late gestation, whereas maintenance and maternal growth are the principal factors affecting amino acid requirements in early gestation (Moehn S. and Ball R., 2013).

Changing amino acid requirements during gestation (Table 2) have important consequences for feeding sows. Since amino acid requirements increase to a much greater degree in late gestation than energy requirements it is nearly impossible to satisfy the requirements by simply feeding more of the same diet in late gestation. If the feed allowance of the same diet is increased sufficiently to cover amino acid intake, the sows will consume excessive amounts of energy. So what is more important: amino acid or energy intake? According to Moehn S. and Ball R. (2013) by (Shelton et al. 2009; Kleisiary, 2007; Kusina et al., 1999) meeting the protein (amino acid) requirement is more important than meeting the energy needs. Parity segregated phase feeding is the ideal tool to meet both the amino acid and energy requirements of pregnant sows of all ages.

Energy balance

When talking about need in energy for maintenance**,** metabolisable energy of maintenance (MEm) does not change throughout gestation. It was set to 440 kJ/kg BW0.75 for a sow with 240 min of standing activity per day (Hansen et al., 2014; Dourmad et al., 2008).

Fetal growth changes throughout gestation. In the first third of gestation, the daily weight accumulation (g/d) is relatively slow compared with fetal growth during the last part of gestation (Hansen et al., 2014). Similar to amino acid requirements, in the 2012 NRC model energy requirements have been divided into six tissue pools for maintenance, growth (maternal protein and fat deposition), foetus, mammary tissue, uterus, and placenta and fluids (Goodband et al., 2013; NRC, 2012). Huge energy requirement is for maintenance and maternal growth (Figure 2). The maintenance requirement can be expressed as 100 × BW0.75 (NRC 2012).

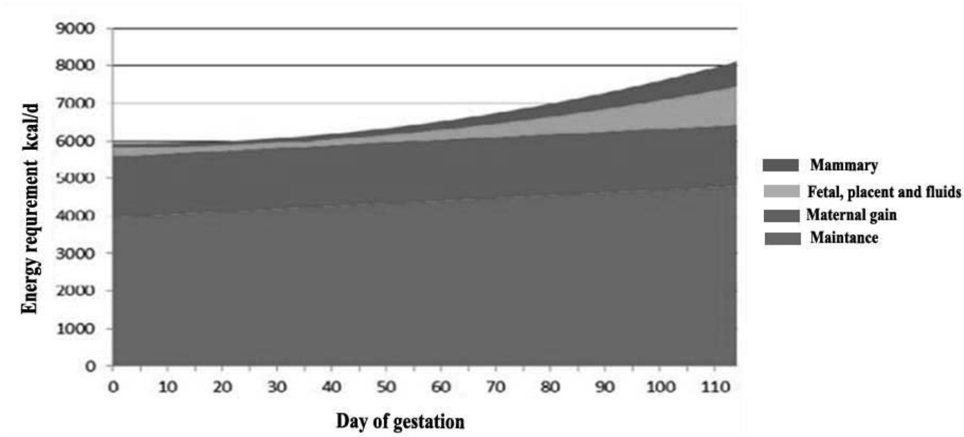

Figure 2. *Energy needs of gilts (kcal/d) during gestation based on different body tissues (Goodband et al., 2013)*

Thus, as BW increases, maintenance energy requirements increase as well. Insufficient amount of energy in the diet leads to slower growth and serious disturbances in reproduction. Excessive increases in fat can also cause negative effects on reproduction (Beuković, 1999; Maletić 2012).

Some studies have even shown that increasing the amount of protein and energy in pregnancy aims to provide the best possible preparation for the next lactation of sows and possibly increase the body weight in newborn piglets (Beuković, 1999; Young and Aherne, 2005; Smits et al., 2008; Maletić, 2012; Goodband et al., 2013). From further reproduction are usually excluded best sows, which had a huge and good litter, because of the insufficient preparation BW for lactation. Weng et al. (2009) observed that sows housed in individual stalls or grouped in pens during gestation on average do not spend more than four hours standing. If individually penned sows are housed at less than 20°C or group housed sows are housed at less than 16°C, additional adjustments must be made for the increased requirement for thermal regulation. Young gilts and second-parity sows will require more energy for weight gain than older sows where BW is simply maintained. In reality, weight gain is dictated by the level of feeding above the requirement for maintenance and requirement for foetal tissue, mammary tissue, placenta, and fluids, so the greatest opportunity for maternal gain is in early gestation, when requirements for foetal tissues and mammary gland growth are relatively low.

Conclusion

NRC model allows users to properly adjust and enter parameters related to production conditions depending on the situation. The model will estimate protein deposition, lipid deposition and bodyweight changes. In gestating sows, these changes will be estimated for several pools, including the sow, the fetuses and the reproductive tissue.

Requirement for SID amino acids is one of the benefits that this model provides. Besides that the sows should have individual amounts applied depending on average body weight and condition, and it should be modified for each sow or group, particularly if they are too lean or too fat. In any case heavier or lighter than average, and more or less efficient in their nutrient utilization. Single diet is not adequate to provide sufficient amino acids in late pregnancy for young sows. Conversely, a single diet provides excess amino acids throughout pregnancy for older sows. The consequence is that the single diet may impair performance of young sows and will waste money because it is over-formulated for older sows.

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