Updating arginine recommendations for swine is an important step towards optimum performance

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Arginine is an essential amino acid in piglets, and it is needed for maximum performance in different phases of swine production. Endogenous arginine synthesized via the urea cycle and the arginine originating from raw materials were considered sufficient to cover arginine requirements. (Easter et al. 1974; Easter and Baker, 1976) Thus, many of the nutrient requirement tables do not include recommendations for arginine. In 1998, NRC had identified relatively low requirements for arginine in pigs, whereas, in 2012, NRC revised the arginine recommendations and came up with higher arginine requirements (Table 1). Modern breeds of pigs need much higher arginine levels in their feed for maximum performance as compared toNRC recommendations (Table 1). Thus, focus of the current article is on arginine requirements in swine.

Table 1. Recommendations of arginine for swine (values are % of arginine in total diet)

	Nursery piglets	Weanling piglets	Growing & Finishing pigs	Gestating Sows	Lactating sows
	5 kg BW	10 kg BW	20 to 100 kg BW	140 kg BW at breeding	
NRC (1998)	0.59	0.54	0.37 (20 kg BW) 0.19 (100 kg BW)	0	0
NRC (2012)	0.75	0.68	0.62 (20 kg BW) 0.38 (100 kg BW)	0.36 (days 0 to 90) 0.47 (days 90 to 114)	0.60 (parity 1) 0.54 (parity 2)
Wu (2014)	1.19	1.01	0.83 (20 kg BW) 0.64 (100 kg BW)	1.03 (days 0 to 90) 1.03 (days 90 to 114)	1.37

(Source : Wu et al. 2018)

Gestating sows

In a short-term study with 2 sows per treatment, arginine free diet did not affect nitrogen balance or body weight of piglets in gestating sows (Easter and Baker, 1976). Similar results were found by Easter et al. (1974). However, it does not mean that sows do not suffer from lack of arginine. It also does not mean that the maximal fetal growth during late part of pregnancy can be achieved without arginine. Modern sows ovulate 20 to 30 oocytes and deliver 10 to 15 live born piglets per litter and fetal mortality is highly related to the uterine capacity and placental growth. Both polyamines and nitric oxide (NO), metabolites of arginine, also have important role in placental development. Moreover, arginine is a major metabolite both in placenta and in allantoic fluid (Wu et al. 1996). Altogether, arginine seems to be a limiting factor in sows thus it has been recently subject of different researches. Arginine supplementation between days 22 and 114 of gestation improved reproductive performance of sows (Table 2), thus improved number of piglets born and their survivability which was related to the higher placental weight in arginine fed sows (Gao et al. 2012). Several papers (Table 3) reported positive effects of extra arginine during pregnancy in swine. Most of the literature indicate an improvement in litter size and litter weight by the addition of 0.80 to 1.0% of arginine to a diet that already contained 0.7 to 1.0% arginine. Arginine intake should be 1.5 to 2% of diet which is reflected in results of three new trials (Table 4). Thus, requirement of pregnant sows for arginine is much higher compared with NRC 2012 (Table 4).

Table 2. Effect of dietary L-arginine on the reproductive performance of sows

Items	Control	Arginine	Pooled SEM
Number of piglets per litter (n)			
Total born	12.46	13.77*	0.35
Born alive	11.25	12.35*	0.51
Stillborn and mummified	1.21	1.42	0.36
Birth weight (kg)			
All piglets born per litter	16.43	17.79	0.68
Piglets born alive per litter	15.82	17.52	0.72
Average for piglets born alive	1.41	1.45	1.41
Placental weight for all live-born piglets (kg)	3.04	3.53*	0.06
Placental weight per live-born piglets (kg)	0.24	0.259	0.011
Birth weight variation of all piglets born alive (kg)	0.229	0.239	0.014

Data are means with pooled SEM, n=108; * P<0.05 versus the control group; (Source : Go et al. 2012)
A variation in birth weights of piglets based on the total number of piglets born alive.

Table 3. Effect of maternal arginine supply during pregnancy on litter size and piglet's weight

Index	Berard and Bee (2010)	Campbell (2009)	De Blasio et al. (2009)	Gao et al. (2012)	Li (2014)	Li (2014)	Mateo et al. (2007)	Ramaekers (2006)	Wu et al. (2012)
Parity of sow	1	1 and MP	1	1 and MP	1	1	1	1 and MP	MP
Supplemental arginine (% of diet or g per sow per day)	0.87% 21.7 g	1% 25 g	1% 25 g	0.87% 16.6 g	0.40% 8.0 g	0.80% 16.0 g	0.83% 16.0 g	1% 25 g	0.83% 16.6 g
Period of arginine supplementation	d 14–28	d 14–28	d 17–33	d 22–114	d 14–25	d 14–25	d 30–114	d 14–28	d 90–114
Feed intake per day (kg)	3.0	ND	2.5	2.0 (d 22–90) 3.0 (d 90–114)	2.0	2.0	2.0	ND	2.0
Dietary CP (%)	14.3	ND	ND	13.2	12.0	12.0	12.2	ND	14.7
Dietary Energy (ME; MJ/kg)	11.5	ND	ND	13.0	12.9	12.9	13.0	ND	13.5
Arginine in basal diet (%)	1.07	ND	ND	0.88	0.70	0.70	0.70	ND	0.78
Lysine in basal diet (%)	0.88	ND	ND	0.65	0.57	0.57	0.58	ND	0.78
Placental weight; early to mid-gestation or at birth	No effect	ND	ND	↑ by 16%	↑ by 34%	↑ by 21%	ND	ND	ND
Litter size of viable fetuses or live born piglets	↑ by 3.7 per litter	↑ by 1 per litter	↑ by 1.2 per litter	↑ by 1.1 per litter	↑ by 2.2 per litter	↑ by 3.7 per litter	↑ by 2.0 per litter	↑ by 1.0 per litter	No effect
Litter weight of viable fetuses or live born piglets	↑ by 32% per litter	↑ by 6.4% per litter	ND	↑ by 11% per litter	No effect	↑ by 32% per litter	↑ by 24% per litter	ND	↑ by 16% per litter

ME = metabolizable energy; ND = not determined; MP = multiparous; ↑ = increase (Source : Wu et al. 2018)

Table 4. Arginine requirements in pregnant sows - a comparison of NRC 2012 and recent trials

Arginine		g/day		%	
Gestation	parity	D 22-90	D 91-114	D 22-114	Arg/Lys ratio
NRC 2012	1	6.5	10.0	0.32/0.42%	**0.52**
NRC 2012	4	4.0	6.8	0.21/0.29%	**0.52**
Trial 1	1.6	34	5.1	1.7%	**2.62**
Trial 2	1	14.2	21.3	0.71%	**1.01**
Trial 3	4.5	22	26.4	0.88%	**1.1**

Lactating sows

Amino acids are not only building blocks of proteins but also have functional roles. Arginine is a precursor of NO which plays an important role in the control of blood flow. Supplementing 0.83 arginine or 50 mg per day NO to diets of sows increased the blood flow to mammary gland and milk production (Kim and Wu, 2009). Feeding arginine at 0.5% and 1% to lactating sows increased arginine content of plasma and milk (Zhu et al. 2017). Arginine also increased insulin and IGF-1 hormones which are underlying factors to improve milk production and composition. Consequently, piglets grew better, and sows were in a better body condition.
In table 5, arginine requirement of lactating sows is summarized and compared with NRC (2012). Lactating sows also have much higher arginine requirements as compared to NRC (2012) recommendations.

Table 5. Arginine requirements in lactating sows - a comparison of NRC 2012 and recent trials

Item	parity	g/d	g/d	g/d
NRC 2012	2+	30.5	0.48%	**0.54**
Trial 1	2.5	65.4	1.23%	**1.26**
Trial 2	4.5	61.1	0.91%	**0.9**

Piglets

Neonatal pigs are very sensitive to arginine deficiency. Arginine deficiency can easily result in hyperammonia in neonatal pigs (Wu et al. 2004). Sows milk is very deficient in arginine and can only provide 0.40 g arginine per kg of body weight per day (Wu et al. 2004). Thus, piglets fed with 0.2 and 0.4% arginine had an improvement in body weight gain (Kim et al. 2004). Supplementation of 0.2 and 0.4% L-arginine to piglets enhanced average daily weight gain by 28 and 66%, and body weight by 15 and 32%, respectively. Yang et al. (2016) also reported that 0.4 and 0.8% arginine supplementation to a milk replacer increased body weight gain of piglets by 19% and 22%, respectively. Arginine is known to enhance blood flow in piglets and concentration of arginine in plasma. An increase in insulin and glucagon concentrations in plasma, like it was mentioned already in sows, is also observed in piglets. Thus, extra arginine is beneficial to piglets indicating an arginine deficiency condition in piglets fed without supplementary arginine. Thus, arginine requirement of piglets (Table 6) are also higher than the recommendations in NRC (2012).

Table 6. Requirements of arginine in piglets - a comparison of NRC 2012 and a recent trial

Arg	body weight	g/d	%	Arg/Lys ratio
NRC 2012	5-7kg	2	0.75%	**0.44**
Trial	2-6kg	2.09	1.12%	**0.51**

Conclusion

The optimum arginine requirement in pigs is often neglected and arginine is deficient in most of the production phases. Thus, the swine industry needs to revisit the arginine specifications in sows and in piglets. Currently, arginine is available commercially in high volumes. Arginine has also been registered as a feed grade amino acid by the European commission. Current arginine prices make it possible to include supplementary arginine in the swine diets to meet the requirements and to improve survivability and growth rate in piglet and reproductive performance in sows.

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