



A review of branched-chain amino acids in lactation diets on sow and litter growth performance

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ABSTRACT

Branched-chain amino acids (BCAA) are three essential amino acids (AA) for lactating sows; however, the effects of dietary Leu, Val, and Ile on sow and litter performance within the literature are equivocal. The BCAA are structurally similar and share the first steps of their catabolism pathway where Leu, Val, and Ile are transaminated through BCAA aminotransferase and irreversibly decarboxylated by the branched-chain α -ketoacid dehydrogenase complex. Although these steps are shared among BCAA, Leu is recognized as the primary stimulator due to Leu's greater affinity towards the enzymes compared to Val and Ile. Since the late 1990s, sows are producing larger and heavier litters and generally consume diets with greater concentrations of Leu and crystalline AA, which may create imbalances among dietary BCAA. Research conducted with growing-finishing pigs confirms that high concentrations of Leu can impair BCAA utilization and growth performance. However, the effects of BCAA on lactating sow and litter performance are not as clearly understood. Within mammary tissue, BCAA uptake is greater than milk output of BCAA since Val, Ile, and Leu are catabolized to form non-essential AA, lactose, fatty acids, and other metabolites. Within the mammary gland, BCAA aminotransferase activity is much higher than within skeletal muscle, liver, or small intestine. Thus, competition among the BCAA, namely, between Leu and Val, can significantly inhibit Val uptake within mammary tissue. Therefore, dietary modifications that mitigate BCAA competition may positively influence Val utilization for colostrum and milk synthesis. Little data exist on Ile and Leu requirements for modern lactating sows. Although Val requirements have been extensively researched in the last 25 yr, an ideal Val:Lys has not been consistently established across experiments. Some studies concluded that total Val concentrations above 120% of Lys optimized performance, whereas others determined that increasing SID Val:Lys from 55% to 136% did not improve piglet growth performance. Although increasing dietary Val positively influences fat and protein composition of colostrum and milk, litter growth during lactation is not always positively affected. Given the competition among BCAA for utilization within mammary tissue, research evaluating the Leu and Ile requirement of modern lactating sows is warranted to fully understand the influence and interactions of BCAA on reproductive and litter growth performance.

Key words: branched-chain amino acids, lactation, litter performance, sow

INTRODUCTION

Structural similarities among the branched-chain amino acids (BCAA) necessary for lactating sow milk protein synthesis can create instances of antagonism and impaired utilization. Leucine, Ile, and Val share the first step of the catabolism pathway where branched-chain amino acid aminotransferase (BCTA) reversibly transaminates the BCAA to their respective α -keto acids. These α -keto acids may then be irreversibly decarboxylated through the branched-chain α -ketoacid dehydrogenase (BCKD) enzyme to produce ketogenic and glucogenic products for utilization in the TCA cycle.

High levels of Leu are commonly present in lactation diets that include corn and corn co-products (NRC, 2012), and thus, utilization and availability of the other BCAA may be impaired. In growing-finishing pigs, BCAA utilization and growth performance declined when diets contained increasing Leu:Lys ratios above 100% of the Leu requirement (Kwon et al., 2019). Furthermore, Cemin et al. (2019) confirmed that increasing Leu:Lys negatively affected growth performance of growing-finishing pigs due to imbalanced Val, Ile, and large neutral amino acids (LNAA) such as Trp.

However, supplemental feed-grade L-Val and L-Ile can mitigate unbalanced BCAA scenarios in diets with high levels of Leu such that growth performance of pigs may be maintained (Kerkaert et al., 2021). This practice has continued to be actively researched and applied for growing-finishing pigs; however, the relationship among BCAA on sow reproductive and litter growth performance is not clearly understood. Amino acid requirements for the lactating female must support milk production for litter growth. Furthermore, metabolism of BCAA within the sow's mammary gland for milk protein synthesis must be considered. The objective of this review is to summarize the current literature on BCAA metabolism on mammary development, colostrum and milk composition, and litter growth performance.

Branched-Chain Amino Acid Metabolism

Metabolism of Ile, Leu, and Val begins after dietary consumption, absorption, and transport from the liver to skeletal muscle for degradation (Harper et al., 1984). These three BCAA share the first step of catabolism where BCTA reversibly transaminates Ile, Leu, and Val to the

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α -ketoacids α -keto- β -methylvalerate, α -ketoisocaproate, and α -ketoisovalerate, respectively. This catabolism step also forms glutamate that can be used for transformation to glutamine and alanine for protein synthesis. After transamination, the α -ketoacids are decarboxylated through the BCKD enzyme in the liver, which is an irreversible process. The final glucogenic and ketogenic products of these catabolism steps include succinyl-CoA and acetyl-CoA for utilization in the TCA cycle for energy production.

Each degradation step is shared among the BCAA and any of the three BCAA can stimulate the catabolism pathway described above. However, Leu is recognized as the primary stimulator of BCKD and BCKD due to Leu's greater affinity towards these enzymes compared to Val and Ile (Harper et al., 1984). Leucine has also been recognized to stimulate protein synthesis through activation of the mTOR signaling pathway within skeletal muscle (Zhang et al., 2017) and for the detection of nutrient and hormone signals from the GI tract to the brain to regulate feed intake (Cota et al., 2006). Additionally, BCAA share brain transporters with other LNAA such as Trp, Thr, Phe, and Tyr (Pardridge, 1977). The ingestion of BCAA and subsequent catabolism creates competition among the BCAA and other LNAA at the blood-brain barrier that can influence transport of LNAA to the brain (Fernstrom, 2005). When a mixture of LNAA including the BCAA is consumed, the conversion of Trp for serotonin activity within the brain may be reduced, which could lead to instances of reduced feed intake (Fernstrom, 2013). Decreased feed intake responses may also be linked to nutrient sensing along the intestinal epithelium. Tian et al. (2019) observed that L-Leu, L-Ile, or a combination of BCAA each stimulated expression of the taste dimeric receptor type 1-member 1/3 (T1R1/T1R3) along the jejunum and increased secretion of cholecystokinin (CCK), a hormone responsible for satiety, in an in vitro porcine model. Furthermore, as stated in a review conducted by Cemin et al. (2019), excess Leu can negatively influence growth performance of growing-finishing pigs if dietary Ile, Val, or LNAA such as Trp are not also considered. However, the relationship of BCAA and LNAA such as Trp on lactating sow performance is not well understood.

Branched-Chain Amino Acids and Sow Mammary Gland Metabolism

There are three phases of rapid mammary gland development for the sow, two of which include the last third of gestation and lactation where nutritional strategies may be implemented to modify colostrum and milk composition (Farmer and Hurley, 2015). Each of the sow mammary glands is distinct with epithelial cells that line alveoli for colostrum and milk synthesis. To satisfy the lactation requirements for milk protein synthesis, the sow mammary gland utilizes large amounts of free AA available in blood plasma (Rezaei et al., 2016). Within mammary tissue, BCAA uptake is much greater than BCAA output in milk. Valine, Ile, and Leu are catabolized to form non-essential amino acids such as glutamine and alanine, lactose, fatty acids, and other metabolites (Trottier et al., 1997; Li et al., 2009; Lei et al., 2012a). To support milk production under instances of insufficient nutrient or AA intake, the sow must mobilize adipose and skeletal muscle tissue (Jones and Stahly, 1999; Shennan and Peaker, 2000). Additionally, AA uptake from plasma may be upregulated to support milk protein synthesis; however, concentrations of Val and Ile within plasma continue to decrease as lactation

progresses (Chen et al., 2018). As lactation progresses and sow body tissue mobilization occurs, concentrations of BCAA within skeletal muscle have been observed to decrease beyond levels initially established pre-partum (Clowes et al., 2005).

Uptake of AA from circulating blood by mammary epithelial cells is influenced by plasma AA concentrations, tissue flux, and AA metabolism for utilization (Rezaei et al., 2016). However, scenarios of AA deficiency or imbalances can alter efficiency and utilization within the mammary gland as necessary for milk production. In one of the first studies to evaluate AA uptake in the modern lactating sow, Trottier et al. (1997) determined that the uptake of AA, especially the BCAA, exceeded milk output of each AA and suggested that there may be biological requirements for mammary gland utilization. Transport of AA within epithelial cells dictates the intracellular availability and potential retention of AA for milk protein synthesis. In bovine mammary epithelial cells, exposure to increasing Leu can increase synthesis of non-essential AA such as alanine, aspartate, glutamate, glutamine, and asparagine (Lei et al., 2012b). Furthermore, competition among the BCAA, namely, between Leu and Val, can significantly inhibit uptake of Val within mammary tissue (Jackson et al. 2000). Thus, dietary modifications to account for competition among the BCAA may positively influence Val or other BCAA utilization by the mammary gland. In a study conducted by Che et al. (2019), providing diets with increasing Val:Lys from 57% to 85% in late gestation increased mammary epithelial cell proliferation and protein synthesis through stimulation of the mTOR pathway, regardless of identical dietary Ile:Lys and Leu:Lys for lactating sows.

Branched-chain amino acid aminotransferase activity within the lactating sow mammary gland is much higher than activity within skeletal muscle, liver, or the small intestine (2.36 vs. 0.66, 0.37, and 0.74 nmol/mg protein per minute, respectively) and 60% of the transaminated BCAA were decarboxylated (Li et al., 2009). Furthermore, glutaminase activity within the mammary gland was not detected. As a result, it is critical to recognize and consider the highly active BCAA catabolism steps within the sow mammary tissue that produce acetyl-CoA from Leu and Ile and succinyl-CoA from Ile and Val. These end-products can subsequently be used for fatty acid synthesis or formation of non-essential AA, such as glutamine, to be excreted in milk.

Changes in the sows' physiological state can also influence AA transport and utilization within the mammary gland. Evaluation of plasma AA pre- and post-partum confirms that most AA including Lys, Met, Thr, and the BCAA increased significantly when the sow transitions from pregnancy to lactation (Chen et al., 2018). However, plasma levels of free AA are not maintained throughout lactation to day 17. As the sow advances in days of lactation, she may mobilize protein tissue to maintain milk synthesis within mammary glands through peak lactation (NRC, 2012; Tokach et al., 2019). To limit mobilization of skeletal muscle and optimize utilization of dietary AA intake for milk protein synthesis, competition, and catabolism among the BCAA within mammary tissue must be considered.

Effects of Branched-Chain Amino Acids on Sow Colostrum and Milk Composition

Recently, studies have evaluated the influence of BCAA on colostrum composition, which may aid the interpretation of discrepancies among recent BCAA sow and litter growth

performance research. Of the three BCAA, Val has been established as the most efficiently transported and utilized amino acid by the mammary gland (Manjarin et al., 2012). Additionally, Val is often recognized as a limiting amino acid for lactating sows (Kim et al., 2001; Soltwedel et al., 2006; Kim et al., 2009), confirming the importance of Val for milk synthesis. However, modifications in BCAA catabolism under varying dietary conditions with excess Leu or limited Ile may influence Val utilization for milk synthesis and subsequent litter growth.

Initial research conducted by Richert et al. (1997b) and Moser et al. (2000) evaluated the interactive effects of Val, Ile, Leu, and total BCAA on both litter growth performance and milk composition. Despite linear increases in dietary Val that improved litter weight gain, there were no reported effects of Val, Val \times Ile, or total BCAA concentrations on milk protein or lactose concentrations (Richert et al., 1997b; Table 1). Although there were no statistical effects of Val, increases of dietary Val from 0.72% to 1.42% appeared to linearly increase milk fat composition. Additionally, increased dietary Ile linearly increased milk protein and fat concentrations. These modifications to milk composition may have supported the author's observed advantage in litter gain during lactation. Moser et al. (2000) also observed linear improvements of increasing Val on litter growth performance. However, this advantage was not supported by modifications to milk composition as the authors reported no influence of Val, Ile, Leu, or total BCAA on milk protein, fat, or lactose composition (Table 2).

Recently, a study conducted by Xu et al. (2017) reported significant improvements in litter weight gain as SID Val:Lys ratios increased from 63% to 123% and observed linear increases in concentrations of essential amino acids within both colostrum and milk. Sows within this study began consuming assigned lactation Val treatments on day 107 of gestation, resulting in potential changes in mammary gland amino acid utilization in the week leading up to farrowing. This might have altered colostrum amino acid composition and then maintained a similar amino acid composition in subsequent milk collected through the rest

of the 28-d lactation period. Another study conducted by Che et al. (2019) evaluated the effects of supplementing Val from day 85 of gestation on protein synthesis of colostrum. In this study, gilts consumed diets with either 0.71% Val (0.57:1.00 Val:Lys) or 1.07% Val (0.87:1.00 Val:Lys). Gilts consuming diets with 1.07% Val produced colostrum with increased protein, fat, lactose, and non-fat solids. In a similar study evaluating effects of Val in late gestation, Che et al. (2020) observed linear increases in colostrum protein, fat, and non-fat solids as dietary Val increased from 0.63% to 0.93% total Val:Lys. The authors also observed linear improvements in piglet weaning weights and average daily gain. The consistently observed modifications to colostrum and milk fat and protein composition due to increasing dietary Val in late gestation with potential to carry over to lactation may explain some of the benefits in reported litter growth performance.

As the BCAA are decarboxylated by BCKA, the carbon skeletons are incorporated into the TCA cycle for energy production. Due to the role of BCAA in energy production and subsequent lipid metabolism of the mammary gland, a study was conducted to evaluate the effects of increasing total BCAA in high-fat (8.0%) lactation diets fed to sows from day 107 of gestation through weaning (Ma et al., 2020). Diets contained similar ratios of Leu:Ile:Val at 2:1:1.5, but increased total BCAA concentrations from 2.85% to 3.24%. Increasing dietary Leu, Ile, and Val from 1.38% to 1.49%, 0.62% to 0.68%, and 0.85% to 1.07%, respectively, significantly increased fat concentration of colostrum but did not influence CP or lactose concentrations in colostrum or in milk collected on days 12 and 18 of lactation. Increased supplementation of BCAA to the high fat diets also increased total fatty acid content of colostrum. Additionally, litter weaning weights and litter ADG increased with increasing total dietary BCAA content, regardless of the same 2:1:1.5 ratios of Leu:Ile:Val. These results and those mentioned previously indicate that total BCAA can alter both the amino acid composition of colostrum and the fatty acid profile of colostrum in a manner that supports enhanced litter growth. Propionyl-CoA, the substrate produced by Val and Ile after the BCKD catabolism

Table 1. Effects of Val and Ile on milk composition, adapted from Richert et al. (1997b)¹

Val, %	0.72			1.07			1.42
Ile, %	0.50	0.85	1.20	0.50	0.85	1.20	0.50
Total BCAA, %	2.57	2.92	3.27	2.92	3.27	3.62	3.27
Diet composition ²							
SID Lys, %	0.92	0.91	0.92	0.90	0.92	0.93	0.94
Ile:Lys	0.53	0.87	1.28	0.52	0.96	1.26	0.51
Leu:Lys	1.49	1.49	1.48	1.49	1.48	1.46	1.45
Val:Lys	0.77	0.80	0.77	1.17	1.15	1.15	1.48
Milk composition, %							
Crude protein ³	5.16	5.31	5.61	4.94	5.39	5.33	5.30
Crude fat ⁴	5.76	6.00	6.67	5.87	6.38	6.66	6.89
Lactose ⁵	4.47	4.48	4.24	4.5	4.29	4.45	4.23

¹A total of 16 sows/treatment were milked between days 14 and 16 of lactation.

²Analyzed chemical composition of dietary treatments.

³Ile linear, $P = 0.005$.

⁴Ile linear, $P = 0.002$.

⁵ $P > 0.05$.

Table 2. Effects of Ile, Leu, and Val on milk composition, adapted from Moser et al. (2000)¹

Val, %	0.80				1.20			
	0.68		1.08		0.68		1.08	
Ile, %								
Leu, %	1.57	1.97	1.57	1.97	1.57	1.97	1.57	1.97
Total BCAA, %	3.05	3.45	3.45	3.85	3.25	3.85	3.85	4.25
Diet composition ²								
SID Lys, %	0.93	0.90	0.91	0.89	0.88	0.87	0.93	0.87
Ile:Lys	0.73	0.78	1.09	1.16	0.74	0.78	1.13	1.14
Leu:Lys	1.60	1.96	1.65	2.01	1.60	2.01	1.60	2.01
Val:Lys	0.86	0.93	0.86	0.91	1.23	1.31	1.18	1.22
Milk composition, %								
Crude protein ³	4.60	4.58	4.49	4.55	4.55	4.47	4.47	4.51
Crude fat ³	5.12	5.40	5.31	5.21	4.95	5.23	5.37	5.43
Lactose ³	5.82	5.75	5.87	5.87	5.89	5.89	5.83	5.87

¹A total of 16 sows/treatment were milked between days 14 and 16 of lactation.

²Analyzed chemical composition of dietary treatments.

³Val, Ile, Leu, and all interactions, $P > 0.05$.

process, can increase circulating endogenous odd-chain fatty acids in mice (Bishop et al., 2020). Although the effects of BCAA on lipid metabolism in lactating sows has not yet been evaluated, colostrum fatty acid composition may be altered if Leu, Val, or Ile influence uptake of circulating fatty acids in mammary tissue. Therefore, it may be important to consider the interactions of energy and amino acid metabolism when evaluating the effects of any or all BCAA on sow reproductive and litter growth performance.

Effects of Branched-Chain Amino Acids on Sow and Litter Performance

Little research has been recently conducted to establish the BCAA requirements for modern, high producing females. Current requirement estimates from the NRC (2012), Brazilian Tables for Poultry and Swine (2017), PIC Nutrition Guidelines (2020), and Danish Nutrient Standards (2020) for BCAA are presented in Table 3. Branched-chain amino acid requirements are variable among nutrition guideline sources, with SID AA:Lys ratios ranging from 0.64 to 0.85 for Val, 0.56 to 0.60 for Ile, and 1.02 to 1.15 for Leu (NRC, 2012; Rostagno et al., 2017; PIC, 2020; Tybirk et al., 2020). The variability among sources is likely a reflection of data availability at the time of publication and interpretation of the data available.

Relatively little data exist on the Ile and Leu requirement of modern lactating sows and literature on these requirements is not reported in the NRC (2012). In contrast, Val requirements of lactating sows have been extensively researched in the last 25 yr, but conclusions across studies were equivocal. Initial evaluation of Val requirement studies evaluated total Val:Lys ratios were not consistent among litter growth characteristics with Richert et al. (1996; 1997a,b) and Moser et al. (2000) observing improvements in litter gain when diets contained 118%, 154%, or 128% Val:Lys, respectively (Table 4). In contrast, Carter et al. (2000) and Gaines et al. (2006) did not observe improvements of Val:Lys above 79%, 86%, or 70%.

Within the last few years, re-evaluation of Val:Lys ratios in lactation diets with modern high producing females also

Table 3. Branched-chain amino acid requirement estimates for lactating sows

Item	NRC (2012)	Brazil (2017) ¹	PIC (2020) ²	Danish Nutrient Standards (2020) ³
SID ⁴				
Lys, %	0.72–0.87	1.04–1.10	1.05	1.00
Val:Lys	0.85	0.83	0.64	0.69–0.74
Ile:Lys	0.56	0.60	0.56	0.56–0.60
Leu:Lys	1.11–1.15	1.15	1.14	1.02–1.08
SID intake, g/d				
Lys	42.2–52.6	64.5–68.9	50.0–62.0	–
Val	35.9–44.9	53.5–57.2	32.0–39.7	–
Ile	23.4–29.4	38.7–41.4	28.0–34.7	–
Leu	47.1–60.3	74.2–79.2	57.0–70.7	–

¹Brazilian Tables for Poultry and Swine (2017).

²PIC Nutrition guidelines (2020).

³Danish nutrient standards (2020).

⁴SID = standardized ileal digestible.

yielded inconsistent responses in sow reproductive performance and litter growth rates when dietary SID Val:Lys ratios ranged from 55% to 105% (Devi et al., 2015; Strathe et al., 2016; Xu et al., 2017; Greiner et al., 2019). Xu et al. (2017) observed linear improvements in litter ADG when increasing SID Val:Lys ratios from 74% to 133% across a small sample size of sows ($n = 24$ sows). In contrast, Strathe et al. (2016) and Greiner et al. (2019) did not report any influence of increasing SID Val:Lys from 55% to 105% on sow performance when evaluated over much larger sample sizes ($n = 558$ and 422 sows, respectively). Beyond dietary modifications, some of the reasons for these differences in response could reflect variations in parity, lactation length, litter size, feed allowance, or start date of dietary treatment intake across studies. Within these experiments, lactation length ranged from 17 to 28 d and pigs weaned per litter ranged from 9.4 to 13.6. Although litter size could influence the observed responses, changes in feed allowance may have also influenced

Table 4. Summarized effects of increasing Val:Lys in lactation diets on litter performance

Study	Range of SID Val:Lys, %	Improved litter gain?	Optimal Val:Lys
Richert et al., 1996	70 to 119	Yes	119%
Richert et al., 1997a	75 to 118	Yes	118%
Richert et al., 1997b	70, 112, and 154	Yes	154%
Moser et al., 2000	78 or 128	Yes	128%
Carter et al., 2000	79 to 136	No	79%
Gaines et al., 2006 (Exp. 1)	86 to 121	No	86%
Gaines et al., 2006 (Exp. 2)	70 to 131	No	70%
Devi et al., 2015	81 or 86	No	81%
Craig et al., 2016	77 to 118	No	77%
Strathe et al., 2016	66 to 105	No	66%
Xu et al., 2017	74 to 133	Yes	113%
Greiner et al., 2019	55 to 102	No	55%

the reported litter performance criteria. In contrast to the study conducted by Xu et al. (2017) where sows were allowed ad libitum access to feed immediately post-farrow, maximum feed intake for sows was limited to 5.5 kg/d (Greiner et al., 2019) or 7.4 kg/d (Strathe et al., 2016) during lactation. Additionally, sows within the Strathe et al. (2016) study did not begin consumption of assigned dietary treatments until 2-d post-farrow, whereas sows within the other studies began consumption of diets approximately 7- or 3-d pre-farrow (Xu et al., 2017 and Greiner et al., 2019; respectively). In combination, these factors may explain the discrepancies in reported litter growth performance among the evaluated Val:Lys ratios.

Although limited literature is available, some researchers have directly evaluated the effects of Ile and total BCAA in addition to increasing Val on sow performance (Richert et al., 1997b; Moser et al., 2000). Within these studies, Ile:Lys ratios ranged from 49% to 135%, Leu:Lys ranged from 133% to 209%, and Val:Lys ratios ranged from 70% to 154%. Both studies observed significant advantages of increasing dietary Val on litter growth performance, but no influence of total BCAA or Leu. However, Richert et al. (1997b) did observe a linear improvement in litter weight gain as Ile:Lys increased from 49% to 121%, indicating that Ile alone, regardless of Val, may influence litter growth. In contrast, the trial conducted by Moser et al. (2000) did not observe any influence of dietary Ile on sow or litter performance, regardless of Val, Leu, or total BCAA composition of the diet.

In summary, some studies that evaluated Val:Lys requirement for lactating sows concluded that total Val concentrations above 120% of Lys optimized litter weaning weights and average daily gain (Richert et al., 1996; 1997a, b; Moser et al., 2000; Xu et al., 2017). In contrast, others determined that increasing SID Val:Lys ratios from 55% to 136% did not improve piglet growth performance (Carter et al., 2000; Gaines et al., 2006; Devi et al., 2015; Craig et al., 2016; Strathe et al., 2016; Greiner et al., 2019). Within some these studies, it is important to note that dietary BCAA content, namely, Leu:Lys ratios, was not controlled across the

treatments evaluated (Moser et al., 2000; Gaines et al., 2006; Craig et al., 2016). However, variation among Leu:Lys ratios does not appear to resolve the discrepancy between studies that observed positive effects of increasing Val:Lys and those that did not observe evidence for differences among increasing Val.

Since the late 1990s, sows are producing much larger and heavier litters and generally consume diets with greater concentrations of Leu and crystalline amino acids, which may create imbalances among the dietary BCAA. Uptake of BCAA by the mammary gland exceeds output of Ile, Leu, and Val in milk which indicates potential retention in mammary tissue for synthesis of non-essential amino acids, protein, lactose, and/or fatty acids. Given the well-established relationship among BCAA and LNAA metabolism pathways, one may hypothesize that Ile, Leu, total BCAA or LNAA such as Trp or Thr may have influenced the observed inconsistent responses among Val:Lys and Ile:Lys in published studies.

CONCLUSION

In review of the available literature, sow and litter growth responses to dietary BCAA and LNAA such as Trp are equivocal. Within the mammary gland of lactating females, catabolism of the BCAA is highly active. The positive influence of Val on fat and protein composition of colostrum and milk has been consistently observed; however, this does not always support enhanced litter growth during lactation. Furthermore, competition among Val, Ile, and Leu for utilization and formation of non-essential AA and fatty acid synthesis within the mammary tissue must be considered when interpreting the influence of dietary BCAA on performance of the lactating sow.

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Conflict of Interest Statement

None declared.

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