The effects of adding spray dried plasma protein and spray dried blood cells to starter diets for pigs.

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Introduction

Dried blood products have been used in the feed industry for many years, and these products have usually been regarded as quality protein sources in starter diets for pigs. However, often the blood proteins and amino acids were partly destroyed during the drying process by the use of ring-, roller-, or drum-driers. The introduction of a more gentle drying process in the form of spray drying approximately 10 years ago have dramatically improved the response obtained by feeding blood products to pigs. In addition, various processing methods are now applied to blood, producing different end products. Two such products are spray dried plasma protein and spray dried blood cells, which are now commonly included in starter pig diets in the US

What is Spray Dried Plasma Protein and Spray Dried Blood Cells?

Spray Dried Plasma Protein (SDPP) is a unique protein source that is produced by the separation of whole blood into a plasma fraction and a cell fraction. Blood is obtained at commercial slaughter facilities where fresh blood from killed animals is collected in stainless steel equipment. Immediately after collection, an anticoagulant is added and plasma is separated from cells by centrifugation (Russell and Weaver, 1996, Unpublished). Each fraction (plasma and cells) is spray dried resulting in a dark powder containing the cell fraction (spray dried blood cells, SDBC) and a light-tan powder containing the plasma fraction (SDPP).

SDPP contains 78 % protein with a relatively high concentration of lysine, tryptophan and threonine, but a relatively low concentration of methionine and isoleucine. The amino acid profile of SDPP as well as the apparent ileal digestibility of individual amino acids is shown in table 1. The proteins included in SDPP are mostly albumins, globins and globulins. The globulin fraction include gamma-globulins which consists of immunoglobulins (Gatnau *et al.*, 1993).

SDBC contains 92 % protein, and is relatively high in lysine and tryptophan, However, also this product is low in methionine, as appears from table 1. The apparent ileal digestibility of amino acids in SDBC is higher than in SDPP, thus, SDBC is a highly digestible source of protein for the young and newly weaned pig.

Response to adding SDPP to starter pig diets

In early experiments, SDPP was included in starter diets for pigs at a level of 10 % replacing soybean meal. In these experiments, it was documented that pigs fed SDPP experienced increased growth rate, feed intake, and feed efficiency during the immediate post weaning period as compared to controls fed no SDPP. (Zimmerman, 1987, Gatnau and Zimmerman, 1990). A similar response to SDPP as compared to soybean meal was reported recently by Touchette *et al.* (1995) and Nessmith *et al.*, (1996).

In subsequent experiments, the performance of pigs fed SDPP was compared to that of pigs fed skim milk powder (Sohn *et al.*, 1991, Hansen *et al.*, 1991a & b, Hansen *et al.*, 1993, Kats *et al.*, 1994, de Rodas *et al.*, 1995), fish meal (Bergstrom *et al.*, 1995, Richert *et al.*, 1995), casein (Gatnau *et al.*, 1995, Cain, 1995), potato protein (Smith *et al.*, 1995), or egg protein (Owen *et al.*, 1993). In all of these experiments, the positive effects of adding SDPP to the diets were demonstrated. In addition, it was demonstrated that SDPP is superior to any other available protein source when fed to newly weaned pigs. Weaver *et al.* (1995a) summarized 25 experiments in which the effects of adding SDPP to starter pig diets were examined and concluded that on average, daily gain had been improved by 39 %, daily feed intake was increased by almost 32 % and feed efficiency was improved by 5.4 %.

The level of optimal inclusion of SDPP in starter diets have been investigated in a few studies. Gatnau *et al.*, (1991) concluded that the inclusion of 6 % SDPP during the post weaning period maximized pig performance. However, Kats *et al.* (1994), also examined the effects of adding graded levels of SDPP to diets fed to newly weaned pigs (21 days of age). Diets containing 0, 2, 4, 6, 8, or 10 % SDPP respectively were formulated by adding SDPP and lactose in stead of skim milk powder. A linear response to SDPP in daily weight gain as well as daily feed intake was observed in this experiment during the first two weeks post weaning, as appears from table 2. Because of these convincing reports, SDPP is now considered a crucial ingredient in starter diets for early weaned pigs in the US. A level of 7.5 - 10 % SDPP in diets fed to pigs younger than 28 days of age is commonly recommended (Weaver, 1996, Unpublished).

Mode of action of SDPP

When pigs are weaned at about 3 weeks of age, the maternal immunoglobulins are removed from their diet. The immunoglobulins in the milk functions to protect the small intestine in the young pig (Wilson, 1974). The removal of the immunoglobulins from the pigs diet may be responsible for the post weaning growth lag which is usually experienced in early weaned pigs, because the pigs own immune system does not reach maturity until approximately 6 weeks of age (Drew and Owen, 1988).

SDPP contains approximately 22 % immunoglobulins. Because of the gentle drying procedure applied to SDPP, the immunoglobulin fraction is not denatured during this process. Hence, they still have potential activity against the specific bacteria and viruses present in the intestinal tract of the pigs (Drew, 1995, Unpublished).

To test the hypothesis that the immunoglobulin fraction per se is indeed the active component in SDPP, several experiments have been conducted. SDPP was separated into a low molecular weight fraction (LMW), an immediate molecular weight fraction (IMW), and a high molecular weight fraction (HMW). The HMW fraction contained most of the immunoglobulins. Diets containing the same amount of each of the three fractions as in SDPP, were formulated, and results obtained in pigs fed each of these diets were compared to performance of pigs fed SDPP. In four separate experiment, it was shown that results similar to or even slightly better than those obtained by feeding SDPP could be achieved by feeding only the HMW fraction. (Cain, 1995, Pierce *et al.*, 1995, Owen *et al.*, 1995a, Weaver *et al.*, 1995b). These results indicate that the active component in SDPP is contained in the HMW-fraction, - this could be the immunoglobulins.

Coffey and Chromwell (1995) examined the effect of adding SDPP to weanling pigs placed either in a commercial nursery or under experimental conditions in a very clean environment. The results obtained in this experiment showed that pigs in the dirty (commercial) environment increased performance as SDPP was added to the diet, whereas no response to the addition of SDPP was obtained in pigs in the clean environment. A similar response was reported by Stahley *et al.* (1994). These researchers concluded that the repons to feeding SDPP is depending on the immune status of the pigs, and that pigs with a high immune system activation benefit the most from being fed SDPP-containing diets as compared to pigs with a low immune system activation. These results could be interpreted as giving further support to the hypothesis of an immunological response rather than a nutritional response in pigs fed SDPP. However, more research in this area is needed before it can be concluded that only the immunoglobulin fraction is responsible for the effects of feeding SDPP to early weaned pigs.

One of the most consistently reported responses to feeding SDPP is an increased feed intake immediately after weaning as compared to other protein sources. Working with mice, it was shown that the increased feed intake results in an increased protein retention, whereas energy retention was not significantly changed, indicating that fat retention was not increased (Thomson *et al*, 1995). Likewise, it was shown that nitrogen digestibility in mice fed SDPP was greater than in mice fed a skim milk powder diet. In addition, liver weights of SDPP fed mice has been shown to be greater than in control mice (Thomson *et al.*, 1994, Thomson *et al.*, 1995). In pigs, it has previously been demonstrated that liver weights are increased with increased feed intake (Newcomb *et al.*, 1993), indicating that higher liver weights is a result of increased metabolism due to higher feed intake.

The increased consumption of diets containing SDPP may be due to greater palatability. Working with newly weaned pigs, Ermer *et al.*, (1994) investigated diet preferences when pigs were given the choice between a diet containing 20 % skim milk powder and a diet containing 8.5 % SDPP. Of a total of 36 pigs, 28 preferred the SDPP diet and seven preferred the skim milk diet. The preference for the SDPP diet became apparent already at day 2 post weaning when 60 % of total feed consumed was the SDPP diet. This preference increased during the following period, and 71 % of total feed consumption during the initial 3 weeks post weaning was the SDPP diet. Thus, it seems resonable to conclude that increased preference for diets containing SDPP is one of the main reasons for the beneficial results reported on feeding SDPP Whether this is simply due to increased palatability or a function of some kind of altered immune status, still remains to be investigated. However, the practical implication of the increased feed intake is that pigs gain weight at a faster rate during the immediate post weaning period, and that the extra feed consumed seems to be utilized for body protein retention with a high efficiency.

Response to the addition of SDBC to starter pig diets.

The use of spray dried blood cells has been investigated in several experiments. Kats *et al.*, (1994a) reported that 2.5 % SDBC fed in combination with 7.5 % SDPP resulted in pig performance superior to either higher or lower levels of the two ingredients. Feng *et al.*, (1996) as well as McMillan (1996, Unpublished) conducted experiments to investigate the effect of replacing high quality fish meals with SDBC in phase two diets for weanling pigs. In both experiments, a common phase 1 diet was fed to pigs during the first week post weaning. After this period, pigs were allotted to one of three dietary treatments containing 0, 1.25 or 2.5 % SDBC. High quality fish meals were replaced on a lysine basis by SDBC in these diets, - hence, as SDBC was increased, fish meal levels in the diets were decreased. The results obtained in both experiments demonstrated that SDBC and high quality fish meals are equally efficient in supporting pig performance during the phase two period, and no differences in pig performance was reported among treatment diets. Therefore, SDBC can be included in the phase 2 diet at the expense of high quality fish meals at an equal lysine level without any negative impact on pig performance.

Biosafety of spray dried blood products

The risk of contaminating feed with detrimental bacterial or viral agents should always be considered, when animal by products are used in feed formulation. Regularly, samples of SDPP and SDBC have been examined for the presence of viruses and salmonella. Samples are examined for such viruses as swine influenza, PRRS, pseudorabies, porcine parvovirus, bovine viral diarrhea, and rabies. No viruses have ever been found in the products (Weaver and Russell, 1995, Unpublished). In addition, samples of liquid plasma have been analyzed and found to be negative, suggesting that when blood is collected from healthy animals, plasma is free of viral contamination. In other experiments, viruses have been added directly to liquid plasma prior to spray drying. No viruses were detected in the products after spray drying, suggesting that spray drying inactivate viruses insuring the safety of the product. Hence, the use of spray dried blood products is safe and animals fed these products are not at any risk of being infected with viruses or diseases.

Considerations when using spray dried blood products in feed formulation

As already mentioned, SDPP and SDBC are now commonly included in starter diets for pigs in the US. However, when formulating diets with these two products, a few considerations need to be taken.

Since SDPP and SDBC are relatively low in the two indispensable amino acids methionine and isoleucine (table 1), it is important that diets be adjusted to maintain a proper level of these two amino acids. Chung and Baker (1992), developed the concept of using a so-called "Ideal Protein", when formulating diets for pigs. Using this concept, each amino acid is added to the diet at a certain ratio relative to lysine (Table 3). According to this concept, it is often necessary to add additional methionine to diets containing SDPP or SDBC in order to maintain the ideal ratio of methionine to lysine in the diet, because methionine is the first or second limiting amino acid in diets containing SDPP (Kats *et al.*, 1994a). Indeed, Owen *et al.*, (1995b & c) demonstrated that a positive response is obtained when diets containing spray dried blood products are furnished with synthetic methionine.

SDPP contains relatively high levels of sodium and chloride - 2.23 % and 0.4 %, respectively. Therefore, by including 5 to 10 % SDPP in starter diets for pigs, the requirements for these two minerals are usually met. However, Mahan *et al.*, (1996) recently demonstrated that the addition of NaCl to diets containing SDPP is beneficial up to a level of at least 0.36 % sodium and 0.34 % chloride. These levels are considerably above current NRC recommendations (NRC, 1988), and it still remains to be revealed why such a high level of sodium and chloride seems to be necessary, when SDPP is included in starter diets. However, at this point, the recommendation is to add at least 0.2 % NaCl to diets containing SDPP regardless of the levels present in SDPP.

Coffey and Cromwell (1995) investigated the effect of adding antimicrobial agents (cobber and antibiotics) to diets containing skim milk powder or SDPP. They reported that the response to the antimicrobial agents was the same regardless of the protein source included in the diet. Hence, it can be concluded that antimicrobial agents are as efficient in diets containing SDPP as they are in diets without SDPP.

The effect of genotype per se on the response to spray dried blood products has not been investigated so far. However, in several experiments, SDPP and SDBC have been tested in countries with genotypes different from the ones used in the US. In the UK, an 78 gramme increase of daily growth rate during the post weaning period was reported in pigs fed SDPP as compared to pigs fed a control diet (Lynch, 1995, Unpublished). Pigs fed SDBC during the phase II period (day 14 to 26 post weaning) had a significant improvement in feed utilization as compared to control pigs. In a dutch experiment, the inclusion of 5 % SDPP in starter diets for pigs was tested against diets without any blood products. The results from this experiment showed an improvement in daily gain as well as in feed utilization in SDPP fed pigs. In addition, a lower incidence of post weaning diarrhea was reported in pigs fed SDPP diets (Peet-Schwering and Binnendijk, 1995, Unpublished). Working at Beijing Agricultural University, China, Wutai *et al.*, (1993, Unpublished) demonstrated, that a positive response on daily weight gain as well as feed utilization is obtained upon the addition of SDPP in starter diets for pigs, indicating that the effects of SDPP in Chinese genotypes are equivalent to those obtained with European and North American genotypes Hence, the use of SDPP and SDBC in pig starter diets seems to be justified regardless of the genotype used.

Diet formulation using SDPP and SDBC

It has been recognized that a phase feeding program during the nursery phase is most suitable to meet the specific requirements of the newly weaned pig. Using this concept, Dritz *et al*, (1993) demonstrated that pig performance can be maximized without increasing diet costs. If pigs are weaned at 3 to 4 weeks of age, a 2 or 3 phase feeding program is usually recommended. In a 2 phase program, one diet is fed from day 0 to 14 post weaning, and a follow up diet is fed from day 14 to day 35 post weaning. Using this approach, the phase 1 diet should contain approximately 1.5 % lysine, 15 to 20 % lactose, 7.5 to 10 % SDPP and 1.25 to 2.5 % SDBC. The phase 2 diet should contain 1.25 % lysine, 2.5 % SDBC, 5 to 10 % lactose and no SDPP. If a 3 phase program is employed, the above phase 1 diet should be fed for only one week post weaning, a phase 2 diet containing 1.4 % lysine, 5 to 7.5 % SDPP, 2.5 % SDBC and 10 to 15 % lactose should be fed from day 8 to day 21 post weaning. The phase 3 diet in this program should contain 1.1 % lysine, 2.5 % SDBC, no SDPP and 0 to 10 % lactose. It is important that the phase 1 diet is fed for at least 1 week, if maximum pig performance should be achieved. If diets are changed before one week post weaning, a decrease in performance has been observed (Stein *et al.*, 1996). If pigs are weaned before 3 weeks of age, a special transition diet should be fed from weaning and until pigs are 3 weeks of age. This diet should have a lysine content of 1.7 % and contain 20 to 25 % lactose, 7.5 to 10 % SDPP and no SDBC.

Conclusion

The use of spray dried blood products has consistently improved pig performance during the post weaning period, which is the reason why these products have become popular in the global swine industry. Although many questions still remains to be investigated regarding the specific mode of action of the products, there is little doubt about the advantages of the inclusion of SDPP and SDBC in starter pig diets. The response to the addition of SDPP has been shown to be the greatest in pigs placed in dirty environments or if they are otherwise immunological challenged. Feed intake is usually higher when SDPP is included in the starter feed, and it has been shown, that pigs prefer to consume a diet containing SDPP. Whether the increased feed intake is due to an immunological response or to greater palatability is unknown at this point. It is important that diets containing spray dried blood products are formulated on the basis of digestible amino acids and that special attention is given to the level of digestible methionine in these diets. In order to obtain the best economic result from feeding these products, a phase feeding program should be implemented during the nursery period, and the level of the spray dried products need to be highest in the phase 1 diet that is fed immediately after weaning.

References

Bergstrom, J. R., J. L. Nelssen, M. D. Tokach, R. D. Goodband, K. Q. Owen, W. B. Nessmith, Jr., B. T. Richert, J. W. Smith II, and S. S. Dritz, 1995. Combinations of select menhaden fish meal and spray-dried plasma protein in the transition diet (fed to pigs from 5 to 7 kg) for the segregated early weaned pig. J. Anim. Sci. 73(Suppl. 1): 74. (Abstract).

Cain, C. M. 1995. Mode of action of spray-dried porcine plasma in weanling pigs. American Association of swine practitioners, p. 225.

Chung, T. K. and D. H. Baker, 1992. Ideal Amino Acid Pattern for 10 kg pigs. J. Anim. Sci., 70:3102.

Coffey, R. D. and G. L. Cromwell, 1995. The impact of environment and antimicrobial agents on the growth response of early weaned pigs to spray-dried porcine plasma. J. Anim. Sci., 73:2532.

de Rodas, B. Z., K. S. Sohn, C. V. Maxwell, and L. J. Spicer, 1995. Plasma protein for pigs weaned at 19 to 24 days of age: Effect on performance and plasma insulin like growth factor 1, growth hormone, insulin, and glucose concentration. J. Anim. Sci., 73:3657.

Drew, M. D. and B. D. Owen, 1988. The provision of passive immunity to colostrum-deprived piglets by bovine or porcine serum immunoglobulins. Can. J. Anim. Sci., 68:1277.

Dritz, S. S, J. L. Nelssen, M. D. Tokach, R. D. Goodband, K. Q. Owen, L. J. Kats, and B. T. Richert. Optimal dietary sequence in a nursery-phase feeding program for segregated early weaned pigs. Kansas State University Swine day, 1993. P. 24.

Ermer, P. M., P. S. Miller, and A. J. Lewis, 1994. Diet preference and meal patterns of weanling pigs offered diets containing either spray-dried porcine plasma or dried skim milk. J. Anim. Sci., 72:1548.

Feng, C. P. Y., C. F. M. de Lange, K. Poulsen, and A. Pharazyn, 1996. Granulated animal blood cells in phase two pig starter diets. Ontario Swine Research Report, 1996, XXXX (submitted).

Gatnau, R. and D. R. Zimmerman, 1990. Spray Dried Porcine Plasma (SDPP) as a source of protein for weanling pigs. J. Anim. Sci. 68 (Suppl. 1): 374. (Abstract).

Gatnau, R., D. R. Zimmerman, T. Diaz and J. Johns, 1991. Determination of optimum levels of spray dried porcine plasma (SDPP) in diets for weanling pigs. J. Anim. Sci (Suppl. 1): 369 (Abstract).

Gatnau, R., C. Cain, R. Arentson, and D. Zimmerman, 1993. Spray-dried porcine plasma as an alternative ingredient in diets for weanling pigs. Pig News and Information, 14:157 N.

Gatnau, R., C. Cain, M. Drew, and D. Zimmerman, 1995. Mode of action of spray dried porcine plasma in weanling pigs. J. Anim. Sci. 73(Suppl. 1):82. (Abstract)

Hansen, J. A., J. L. Nelssen, and R. D. Goodband, 1991a. Evaluations of plasma proteins and meat extract as replacement for dried skim milk in swine starter diets. J. Anim. Sci. 69(Suppl.1): 372 (Abstract).

Hansen, J. A., R. D. Goodband, J. L. Nelssen, K. G. Friesen, and T. L. Weeden, 1991b. Effect of substituting spray-dried porcine plasma protein for nilk products in starter pig diets. J. Anim. Sci. 69(Suppl.1): 103 (Abstract).

Hansen, J. A., J. L. Nelssen, R. D. Goodband, and T. L. Weeden, 1993. Evaluations of animal protein supplements in diets of early weaned pigs. J. Anim. Sci., 71: 1853.

Kats, L. J., J. L. Nelssen, M. D. Tokach, R. D. Goodband, J. A. Hansen, and J. L. LAurin, 1994. The effect of spray-dried porcine plasma on growth performance in the early-weaned pig. J. Anim. Sci. 72:2075.

Mahan, D. C., E. M. Weaver, and L. E. Russell, 1996. Improved postweaning pig performance responses by adding NaCl or HCL to diets containing animal plasma. J. Anim. Sci., 74(Suppl. 1):58. (Abstract).

Nessmith, Jr, W. B., M. D. Tokach, R. D. Goodband, J. L. Nelssen, J. R. Bergstrom, and K. Q. Owen, 1996. Interactions between lactose, spray-dried plasma protein, and soybean meal in diets for segregated early weaned pigs (SEW). J. Anim. Sci. 74 (Suppl. 1): 56. (Abstract).

Newcomb, M. D., R. S. Ott, T. van Kempen, Y. H. Lan, F. K. McKeith, J. E. Novakofski, P. J. Bechtel, and R. A. Easter. Effect of hyperalimentation on body composition in swine. J. Anim. Sci. 71:144.

NRC, 1988. Nutrient requirements of swine. Ninth revised edition.

Owen, K. Q., J. L. Nelssen, M. D. Tokach, R. D. Goodband, L. J. Kats, 1993. Spray-dried egg protein in early weaned starter pig diets. J. Anim. Sci. 71 (Suppl. 1): 58. (Abstract).

Owen, K. Q., J. L. Nelssen, R. D. Goodband, M. D. Tokach, K. G. Friesen, B. T. Richert, J. W. Smith, and L. E. Russell, 1995a. Effects of various fractions of spray-dried porcine plasma on performance of early weaned pigs. J. Anim. Sci., 73(Suppl. 1):81. (Abstract).

Owen, K. Q., J. L. Nelssen, R. D. Goodband, M. D. Tokach, L. J. Kats and K. G. Friesen, 1995b. Added methionine in starter pig diets containing spray dried blood products. J. Anim. Sci. 73:2647.

Owen, K. Q., J. L. Nelssen, R. D. Goodband, M. D. Tokach, and S. S. Dritz, 1995c. The efffect of dietary methionine and its relationship to lysine on growth performance of the segregated early pig. J. Anim. Sci., 73:3666.

Pierce, J. L., G. L. Cromwell, M. D. Lindemann, and R. D. Coffey, 1995. Assessment of three fractions of spray-dried porcine plasma on performance of early weaned pigs. J. Anim. Sci., 73(Suppl. 1):81. (Abstract).

Richert, B. T., J. W. Smith II, M. D. Tokach, R. D. Goodband, and J. L. Nelssen, 1995. Comparison of Norse LT-94 (Herring meal) to other protein sources in early weaned starter pig diets J Anim Sci 73(Suppl. 1):75 (Abstract)

Smith II, J. W, B. T. Richert, R. D. Goodband, J. L. Nelssen, M. D. Tokach, L. J. Kats, K. Q. Owen, and S. S. Dritz, 1995. Evaluation of potato protein in starter pig diets. J. Anim. Sci. 73(Suppl. 1):76. (Abstract).

Sohn, K. S., C. V. Maxwell, and D. S. Bachanan, 1991. Plasma protein as an alternative protein source for early weaned pigs. J. Anim. Sci. 69(Suppl. 1): 362.

Stahley, T. S., S. G. Swenson, D. R. Zimmerman, and N. H. Williams, 1994. Impact of porcine plasma proteins on postweaning growth of pigs with a low or high level of antigen exposure. ISU Swine Research Report, Iowa State University, 1994, p. 3.

Stein, H. H., R. A. Easter, W. Guan, D. Li., F. Chi, E. M. Weaver, and L. E. Russell, 1996. Effect of dietary spray-dried plasma protein on postweaning pig growth performance - the optimal inclusion level and feed allowance. J. Anim. Sci., 74 (Suppl1):XXXX (Submitted, Abstract).

Thomson, J. E., E. E. Jones, and E. J. Eisen, 1994. Effect of spray-dried porcine plasma protein on feed intake, growth rate , and effeciency of gain in mice. J. Anim. Sci., 72:2690.

Thomson, J. E., E. E. Jones, and E. J. Eisen, 1995. Effect of spray-dried porcine plasma protein on growth traits and nitrogen and energy balance in mice. J. Anim. Sci., 73:2340.

Touchette, K. J., S. D. Crow, G. L. Allee, and M. D. Newcomb, 1995. Lactose response is dependent on plasma in the diet of weaned pigs. J. Anim. Sci. 73(Suppl. 1): 171. (Abstract).

Weaver, E., L. Russell, and M. Drew, 1995a. Effect of blood protein source on post-weaning performance of pigs. In: Proc. CFIA Eastern Nutrition Conf., Preconf. symp. May, 1995, Montreal, Canada.

Weaver, E. M., L. E. Russell, and M. D. Drew, 1995b. The effects of spray dried animal fractions on performance of newly weaned pigs. J. Anim. Sci., 73(Suppl. 1):81. (Abstract).

Wilson, M. R., 1974. Immunological development of the young pig. J. Anim. Sci., 38:1105.

Zimmerman, D. R., 1987. Porcine Plasma in diets for weanling pigs. Iowa State University Swine Reports, 12-16.

Table 1. Total amino acid profile and apparent ileal digestibility of amino acids in SDPP

Nutrient	Total AA (%)		Apparent ileal digestibility	
	SDPP *	SDBC **	SDPP	SDBC
Protein	78	92	73	93
Lysine	6.9	9.0	84	100
Threonine	4.8	3.6	77	92
Methionine	0.7	0.8	61	97
Cysteine ***	1.8	0.6	-	-
Tryptophan ***	1.3	1.2	-	-
Histidine	2.5	7.5	87	100
Isoleucine	2.0	0.6	80	79
Leucine	7.4	13.4	82	97
Valine	5.2	9.2	81	97
Arginine	4.5	4.0	81	94
Phenylalanine	4.8	7.1	81	96
Tyrosine	4.0	2.2	79	84
Alanine	3.9	7.6	78	97
Aspartic acid	7.2	11.4	80	100
Glutamic acid	11.2	8.7	86	100
Glycine	2.6	4.7	64	85
Serine	4.3	4.4	77	92

Knabe *et al.*, 1994. Unpublished data.
* AP 920 from American Protein Corporation, Ames, IA, USA.
** AP 301 from American Protein Corporation, Ames IA, USA.
*** Ileal digestibility not determined.

Table 2. Efects of feeding graded levels of SDPP during the post weaning period (day 0 to 14).

SDPP (%)	0	2	4	6	8	10	cv
ADG, g*	165	206	217	240	247	255	13.64
ADFI, g **	206	244	256	290	302	300	9.64
G/F	0.79	0.84	0.85	082	0.81	0.84	7.85

* Linear effect of SDPP. Kats *et al.*, 1994a.
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in mice. J. Anim.
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Table 3. Ideal Amino acid profile in pig starter diets.

Amino acid	Relative inclusion
Lysine	100
Arginine	42
Histidine	32
Tryptophan	18
Isoleucine	60
Leucine	100
Valine	68
Phe + Tyr	895
Methionine	30
Met + Cys	60
Threonine	65

Chung and Baker, 1992.

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