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Effects of spray-dried porcine plasma replacement with tryptophan, pyridoxine, and niacin supplementation on feed intake and growth performance of weaning piglets

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Abstract: The purpose of this experiment was to investigate the effects of feeding a low crude protein diet with supplemental dietary tryptophan in combination with pyridoxine and niacin compared with spray-dried porcine plasma (SDPP) supplementation on the performance and feed intake of weaning pigs. A total of 36 crossbred (Landrace × Yorkshire × Duroc) weaned female pigs of 28 days old were reared under three dietary treatments. Treatments were 1) corn-soybean meal diet, 2) 0.30% synthetic tryptophan + pyridoxine + niacin, and 3) 5% SDPP. The experimental results indicated no significant difference (P > 0.05) in feed intake for pigs fed the three experimental diets. However, pigs fed the synthetic tryptophan + pyridoxine + niacin diet tended to have better feed intake than those with other treatments, especially during the first 2 weeks after weaning. At the end of the experimental period, pigs fed synthetic tryptophan + pyridoxine + niacin and a basal control diet tended to have the same weight gain and feed efficiency when compared to pigs fed diets with 5% SDPP (P > 0.05). Therefore, the present study suggests that supplemental tryptophan in combination with pyridoxine and niacin may be used as an alternative for SDPP in weaning piglet diets.

Key words: Feed intake, niacin, pyridoxine, spray-dried porcine plasma, tryptophan, weaning piglets

1. Introduction

Feed intake is a key factor affecting pig performance. Piglets can grow faster if they eat more after weaning (1). Spray-dried porcine plasma (SDPP) is a high-quality protein source in diets for weaned pigs. That SDPP can improve feed intake of weaning pigs has been shown in many reports (2–6). SDPP can be included in pig diets up to 10% (3). The minimum level required to increase newly weaned pig growth performance has been reported to be 5% (1,7). The inclusion of SDPP in the diet of weaning pigs improves feed intake, and growth is more beneficial during the first week after weaning (8). However, to stimulate feed intake of newly weaned pigs by supplementation with SDPP usually makes the diets more expensive. Hence, the present study tried to find a protein source that can be used as an alternative.

The use of low-protein diets supplemented with essential amino acids may reduce feed costs and decrease nitrogen excretion from livestock. A low-protein diet usually has low soybean meal and high corn in the diet. Corn is low in several of the essential amino acids but has been shown to be first-limiting in tryptophan (Trp) and second-limiting in lysine (9,10). The low level of the amino acid Trp in corn protein has been one of the important factors limiting the amount of this cereal grain in swine diets (11).

SDPP contains 78% protein with a relatively low concentration of methionine and isoleucine, but a relatively high concentration of Trp (12–14). Trp plays an important role as the immediate precursor of serotonin synthesis. Henry et al. (15) demonstrated that large neutral amino acids (LNAAs) in pigs have been shown to compete with Trp for passage through the blood/brain barrier, prior to serotonin synthesis in the brain. They reported that the Trp/LNAA ratio was one of the important factors in pig appetite. Blodgett et al. (16) reported that Trp can be converted to niacin. They suggested that Trp may function as a metabolic precursor of niacin. Pyridoxal phosphate (PLP) is the metabolically active ingredient of vitamin B6. PLP is the active form and is a cofactor in many reactions of amino acid metabolism (17). PLP is also an essential component of two enzymes that convert methionine to cysteine (18). It is also required for the conversion of Trp to niacin (19). According to Jantasin and Hsia (20), providing pigs with supplemental Trp in combination with vitamin B6 or niacin for weaning pigs improved

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growth performance better than only supplementing Trp alone in a low crude protein diet. However, there is very little published information on supplemental Trp in combination with pyridoxine and niacin in a diet of newly weaned pigs. Therefore, the purpose of this study was to examine whether supplemental Trp in combination with pyridoxine or niacin could improve feed intake and growth performance as well as SDPP.

2. Materials and methods

2.1. Experimental materials and procedures

The study was conducted in the nursery house of the farm of the National Pingtung University of Science and Technology, Taiwan, Republic of China. Three-way crossbred (Landrace × Yorkshire × Duroc) females were used as experimental animals. A total of 36 pigs, which were weaned at approximately 28 days of age, were distributed into 3 treatments randomly. Each treatment had 4 pens. Each pen had 3 piglets. There were 12 replicates for weight gain and 4 replicates for feed intake and feed efficiency. The experiment lasted for 8 weeks.

Calculated composition of the experimental diets is presented in Tables 1 and 2. Three experimental diets, which contained 0.22% total Trp, were formulated to meet National Research Council (13) recommendations, except for Trp supplementation in dietary treatment 2, which used synthetic Trp formulated to contain 2 times the National Research Council (13) requirement. The diets were formulated to be isocaloric and isonitrogenic to meet the nutrient requirements of piglets.

Treatment 1: Control diet (12% crude protein), Trp content 0.22%.

Treatment 2: 12% crude protein with 0.30% synthetic Trp + pyridoxine + niacin, Trp content 0.44%.

Treatment 3: 12% crude protein with 5% SDPP, Trp content 0.22%.

Table 1. Composition and calculated nutrient content of dietary treatments (% on as fed basis).

Ingredients	Control	Tryptophan + pyridoxine + niacin	SDPP
Corn	81.50	81.90	85.50
Dehulled soybean meal	10.70	10.10	1.90
Soybean oil	3.00	3.00	3.00
Dicalcium phosphate	1.90	1.90	1.50
Limestone	0.80	0.80	1.20
L-Lysine HCL	0.70	0.70	0.60
DL-Methionine	0.50	0.50	0.50
L-Threonine	0.20	0.20	0.20
Salt	0.40	0.40	0.40
Mineral premix[1]	0.10	0.10	0.10
Vitamin premix	0.10	0.10	0.10
L-Tryptophan	0.10	0.30	-
Spray-dried porcine plasma	-	-	5.00
Calculated nutrient content, on as-fed basis			
ME, kcal/kg[2]	3500	3500	3500
Crude protein,%	12.40	12.40	12.40
Calcium,%	0.80	0.80	0.80
Phosphorus,%	0.40	0.40	0.40
Lysine,%	1.19	1.19	1.19
Methionine + cysteine,%	0.70	0.70	0.70
Threonine,%	0.63	0.63	0.63
Tryptophan,%	0.22	0.44	0.22

[1]Supplied individually per kilogram of diet: Fe, 150 g; Cu, 30 g; Mn, 60 g; Zn 120 g; Co 0.7 g; I, 1.5 g; Se, 0.3 g.
[2]ME is calculated, whereas all other values are analyzed.

Table 2. Composition of vitamin premix in experimental diets[1] (grams, as-fed basis).

Item	Control	Tryptophan + pyridoxine + niacin	SDPP
Vitamin B6 (pyridoxine)	0.153	0.306	0.153
Vitamin B3 (niacin)	1.256	2.513	1.256
Vitamin K3	0.100	0.100	0.100
Vitamin B12	0.150	0.150	0.150
Calpan	0.918	0.918	0.918
Vitamin B1	0.102	0.102	0.102
Vitamin B2	0.375	0.375	0.375
Folic acid	0.031	0.031	0.031
Biotin	0.250	0.250	0.250
Choline	66.667	66.667	66.667
Vitamin E	20.000	20.000	20.000
Vitamin A/D3	0.175	0.175	0.175

[1]Vitamin premix was supplied on a corn-based carrier.

Pigs were housed in partially slotted and solid concrete floor pens, with an automatic watering cup and heating lamp. Feed and water were provided ad libitum during the entire experimental period of 8 weeks. Feed was provided in a mash form in the feeder. The feeders were checked twice daily at 0600 and 1800 hours to remove and weigh the residue in the feeder and also to make sure the feeder was not empty. Feed refused and feed supplied were carefully weighed prior to feeding times. The amount of feed was about 0.5 to 1 kg more than the pigs could eat. Every evening, the residue in the feeders was collected in a plastic container and weighed. The daily feed consumption and weekly body weight were recorded for average daily feed intake (ADFI), average daily weight gain (ADWG), and feed efficiency (FE) calculations.

2.2. Statistical analysis

For each animal, ADFI, ADWG, and FE ratios were calculated based on a weekly basis using the following formulas: ADFI = total weekly feed intake/7; ADWG = total weekly weight gain/7; FE = ADWG/ADFI. The experimental data were analyzed as a randomized complete block design with one pen as the experimental unit. Pigs were blocked on the basis of initial weight, and analysis of variance was performed using the general linear model procedure of SAS software (21). Differences among treatment means were determined using Duncan's new multiple range test at $P < 0.05$ significance level.

3. Results

Feed intakes of pigs fed the experimental diets are presented in Table 3. There were no significant differences ($P > 0.05$) of feed intake observed in any treatment. However, during the initial 2 weeks after weaning (weeks 1–2), pigs fed treatment 2 (0.30% synthetic Trp + pyridoxine + niacin) tended to have better feed intake among the dietary treatments.

Effects of dietary treatment on weight gain of piglets are shown in Table 4. The results showed that weight gain was not affected by dietary treatment ($P > 0.05$). However, a similar trend was observed for the dietary treatments in which piglets supplemented with 0.30% synthetic Trp + pyridoxine + niacin had the greatest weight gain during weeks 1–2.

As shown in Table 5, during weeks 1–2 of the trial, pigs fed diets containing 5% SDPP had the greatest feed efficiency, but the effect was not significant ($P > 0.05$). However, during weeks 1–2 and onward pigs consuming the Trp diet (0.30% synthetic Trp + pyridoxine + niacin) and the basal control diet showed better feed efficiency than pigs fed the 5% SDPP diet.

4. Discussion

Many investigators have presented the positive effects of SDPP in weaning pig diets. On the other hand, few studies have been conducted to evaluate the efficiency of pyridoxine and niacin supplementation with Trp on feed intake of weaning piglets. The results of the present study

Table 3. Effect of diet on feed intake of the experimental piglets (g/day).

Weeks	Control	Tryptophan + pyridoxine + niacin	SDPP	SEM[1]	Sig.[2]
1–2	348.68	386.58	343.76	28.98	ns
3–4	580.31	568.21	523.62	42.65	ns
5–6	781.20	661.90	762.60	77.76	ns
7–8	824.50	797.80	870.90	100.99	ns
1–4	464.50	477.39	433.69	27.06	ns
5–8	802.80	729.80	816.80	87.35	ns
1–8	636.66	603.61	625.22	48.44	ns

[1]SEM: Standard error of the mean.
[2]Probability of significance: ns, not significant, P > 0.05.

Table 4. Effect of diet on weight gain of the experimental piglets (g/day).

Weeks	Control	Tryptophan + pyridoxine + niacin	SDPP	SEM[1]	Sig.[2]
1–2	139.94	151.97	120.56	27.92	ns
3–4	287.78	229.61	215.00	34.47	ns
5–6	402.26	281.55	301.96	38.48	ns
7–8	330.12	323.69	326.67	24.88	ns
1–4	219.92	190.79	166.01	18.89	ns
5–8	389.66	302.62	331.31	30.54	ns
1–8	304.79	246.70	248.66	23.68	ns

[1]SEM: Standard error of the mean.
[2]Probability of significance: ns, not significant, P > 0.05.

Table 5. Effect of diet on feed efficiency of the experimental piglets (g feed/g).

Weeks	Control	Tryptophan + pyridoxine + niacin	SDPP	SEM[1]	Sig.[2]
1–2	3.27	4.15	3.00	1.04	ns
3–4	2.95	2.62	3.45	0.35	ns
5–6	2.21	2.51	3.11	0.21	ns
7–8	2.86	2.53	3.21	0.29	ns
1–4	3.11	3.38	3.48	0.44	ns
5–8	2.41	2.52	3.16	0.22	ns
1–8	2.71	2.95	3.17	0.19	ns

[1]SEM: Standard error of the mean.
[2]Probability of significance: ns, not significant, P > 0.05.

indicated that there was a tendency for the combination of Trp, pyridoxine, and niacin in the low crude protein diet to improve feed intake. These results were consistent with previous studies reported by Hsia (1) that raising the level of Trp from 0.177% to 0.237% in a corn-soybean meal, meat-and-bone meal diet increased the feed intake of weaning pigs during the first 2 weeks after weaning. These authors suggested that pigs ate more when 5% SDPP (0.237% Trp) was included in the corn-soybean meal diet, as compared to the corn-soybean meal diet (0.237% Trp) supplemented with 10% meat-and-bone meal. This might be due to the Trp availability, which is low in meat-and-bone meal (1).

In agreement with the present study, Van Dijk et al. (8) reported that the positive effect of SDPP on weight gain is much more pronounced in the first than the second week after weaning. This also agrees with the results obtained by Smith et al. (7), who reported greater weight gain for 0 to 14 days than for those fed 5% SDPP 0 to 14 days after weaning. They also found that during days 0 to 7 of the trial, pigs fed any of the plasma sources had increased weight gain and were heavier on day 7 than pigs fed the control diet ($P < 0.05$). Thacker (22) reported that SDPP is relatively low in the two indispensable amino acids, methionine and isoleucine. These observations indicated that the poorer performance of SDPP in the weeks following weaning might be due to an inadequate supply of amino acids when supplemental SDPP was added to a low crude protein diet.

The findings in this study are contrary to those of Angulo and Cubiló (23), who reported that for the whole trial period, pigs receiving SDPP had better feed efficiency than those receiving no SDPP ($P < 0.05$). In contrast, one study found that SDPP improved feed efficiency in the first week after weaning ($P < 0.05$) but not in the second week after weaning (8). Hansen et al. (2) also demonstrated that pigs previously fed SDPP had greater feed intake and poorer feed efficiency ($P < 0.05$). Therefore, insufficient dietary methionine may have limited pig performance in diets containing SDPP (3,24).

From the results obtained in this study, it was also noted that pigs fed Trp in combination with a pyridoxine and niacin diet showed the best feed intake during the overall periods of weeks 1–2 and weeks 1–4 (Table 3). Weight gain (Table 4) also showed the same trend as feed intake. In this experiment, the Trp supplementation in combination with pyridoxine and niacin showed beneficial effects only during the starter period. This can be explained by dietary amino acid imbalance. According to Dong and Pluske (25), an excess or insufficiency of essential nutrients to some extent generally makes animals eat less. This imbalanced diet normally leads to lower feed intake, and therefore decreases growth performance in animals (25–27).

The piglets had higher performance in the high Trp treatment. This result is in agreement with previous studies in which the replacement of soy protein concentrate by Trp supplementation resulted in positive responses (1,15,20). PLP is a coenzyme for a critical reaction in the synthesis of niacin from Trp; thus, adequate vitamin B6 (pyridoxine) decreases the requirement for dietary niacin (19). Providing pigs with the supplemental Trp in combination with vitamin B6 or niacin for weaning pigs greatly improves growth performance in comparison to only supplementing Trp alone in a low crude protein diet (20). Based on our results, there was a tendency for increased growth performance with the inclusion of synthetic Trp + pyridoxine + niacin throughout the entire 8-week study. The results of the present experiment suggest that it is possible to combine synthetic Trp with pyridoxine and niacin in a diet for newly weaned pigs.

In conclusion, the results of the present study demonstrated that supplemental synthetic Trp with pyridoxine and niacin tended to have the same feed intake and growth performance when compared to pigs fed diets with 5% SDPP. Furthermore, it seems that SDPP can be replaced with synthetic Trp in combination with pyridoxine and niacin without any negative effects on pig performance. Therefore, it can be concluded that supplemental synthetic Trp in combination with pyridoxine and niacin can be used as an alternative for SDPP in low crude protein diets for newly weaned piglets.

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