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Addition of Protease to Standard Diet or Low-Protein, Amino Acid-Supplemented, Sorghum-Soybean Meal Diets for Growing-Finishing Pigs

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Abstract: Low-protein diets supplemented with amino acids help to reduce nitrogen excretion from pig facilities; the exogenous enzymes improve the feedstuffs utilization. So, two experiments were conducted to evaluate the effects of a protease added to sorghum-soybean meal standard or low-protein diets on Average Daily Gain (ADG), Average Daily Feed Intake (ADFI), Feed: Gain Ratio (FGR), Fat Free Lean Gain (FFLG), Backfat Thickness (BT), Longissimus Muscle Area (LMA), Lean Meat Percentage (LMP) and Plasma Urea Nitrogen (PUN) concentration of growing and finishing barrows. Weekly data (ADG, ADFI and FGR) were analysed with PROC MIXED; other data were analysed with PROC GLM. In experiment 1, 32 growing (29.18±5.05 kg initial weight) barrows were individually alloted into 1.2×1.5 m pens in a complete block design with factorial 2×4 arrangement of two levels of CP (16 and 11.5%) and four of protease (0.00, 0.25, 0.50 and 0.75 kg t^{-1}), with eight treatments (T) and four replicates per treatment. Diets (CP% and kg t^{-1} protease) were as follows: T1) 16, 0.0; T2) 16, 0.25; T3) 16, 0.5; T4) 16%, 0.75; T5) 11.5, 0.00; T6) 11.5, 0.25; T7) 11.5, 0.5; and T8) 11.5, 0.75, respectively. There was no effect of protein nor of enzyme level on all variables, except for PUN that was reduced as CP was lowered in the diet. The interaction of factors tended to affect FFLG. The mixed effect analysis showed an effect of time (week) on ADG, ADFI and FGR. In experiment 2, 32 finishing (56.77±5.38 kg initial weight) barrows were used in a completely randomized design with a factorial 2×4 arrangement of two levels of CP (14 and 9.5%) and four of protease (0.00, 0.25, 0.50 and 0.75 kg t^{-1}), with eight treatments (T) and four replicates per treatment. The initial weight was used as a covariate for statistical analysis of data. The treatments (CP% and kg t^{-1} protease) were as follows: T1) 14, 0.0; T2) 14, 0.25; T3) 14, 0.5; T4) 14%, 0.75; T5) 9.5, 0.00; T6) 9.5, 0.25; T7) 9.5, 0.5; and T8) 9.5, 0.75, respectively. The CP reduction negatively affected ADG and FFLG and reduced PUN concentration, but increased FGR. Increasing the protease level increased the PUN. The interaction of both factors affected PUN of pigs. The mixed procedure showed a fixed effect of initial weight on ADFI and ADG; of time (week) on ADFI, ADG and FGR; and of protein level on ADG. These results indicate that protease supplementation to standard- and low-protein, sorghum-soybean, amino acid-supplemented diets, does not improve the growth performance of growing-finishing pigs; that the protein level does not affect the carcass characteristics and that the plasma urea nitrogen concentration is reduced when dietary protein is reduced.

Key words: Growing-finishing pigs, sorghum-soybean meal diets, protease, low-protein diets, plasma urea nitrogen concentration

INTRODUCTION

The substitution of soybean meal by sorghum grain is a way to reduce the Crude Protein (CP) in diets for pigs. An alternative to improve the nutritive value of feedstuffs is the supplementation with exogenous enzymes, especially proteases. So, the addition of enzymes to animal feed increase the efficiency of digestion[1]. The last evidences in growing pigs fed low-protein diets based on corn- or sorghum-soybean meal, indicate that CP can be reduced by four percentage units[2], supplementing with crystalline Amino Acids (AA), without affecting pig growth performance[3,4]. The weight gain is similar between pigs fed low-protein, amino acid-supplemented diets and pigs fed standard CP level[3]. However, pigs fed low-protein, amino acid-supplemented diets have more fat in the carcass, compared to pigs fed standard CP diets[4,5,6]. In finishing pigs fed corn- or sorghum-soybean meal, low-protein, amino acid-supplemented diets have shown inconsistent results[6,7,8] suggesting that there are antinutritional factors in the ingredients used[9] that reduce digestibility of nutrients and provoke digestive

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problems, not allowing pigs to express their maximum genetic potential for growth. An improvement of feed efficiency in growing pigs fed corn-soybean meal diets supplemented with exogenous protease has been reported[10]. There is no information on the use of sorghum-soybean meal diets supplemented with exogenous protease for pigs. The objective of this research was to analyse the effects of adding a protease to sorghum-soybean meal, standard or low-protein diet, on the growth performance, carcass characteristics and plasma urea nitrogen concentration of growing and finishing pigs.

MATERIALS AND METHODS

Experiment 1: This research was conducted in the Experimental Swine Unit of the *Colegio de Postgraduados* in Tecámac, State of México, México. The site has an average temperatura of 12.3°C (-5.0°C minimum, 27.0°C maximum); inside the rooms, the temperature was between 12 and 14°C warmer. In experiment 1, 32 growing (29.18±5.05) crossbred (Yorkshire×Duroc×Pietrain) barrows were randomly alloted into single (1.2×1.5 m) concrete floor pens, equipped with a feeder and a niple waterer, in a complete block design with a factorial 2×4 (eight treatments) arrangement with four replicates per treatment. The blocking criterion was the initial weight of pigs. This experiment lasted 28 d. Pigs had free acces to feed and water. The experimental diets (treatments) were sorghum-soybean meal based and the varition was the CP level (16 and 11.5%) and the level of exogenous protease (0.00, 0.25, 0.50 and 0.75 kg t^{-1}). The treatments (T) were as follows: T1) 16.0 and 0.00, control; T2) 16.0 and 0.25; T3) 16.0 and 0.5; T4) 16.0 and 0.75; T5) 11.5 and 0.00, control; T6) 11.5 and 0.25; T7) 11.5 and 0.5; and T8) 11.5 and 0.75, respectively Table 1. The CP levels evaluated in this experiment were obtained from previous

Table 1: Composition of the experimental diets for growing pigs (experiment 1)

		Treatment							
Ingredient, %		T1[1]	T2	T3	T4	T5	T6	T7	T8
Sorghum		76.14	76.09	76.04	75.99	87.59	87.53	87.48	87.43
Soybean meal, 44%		20.44	20.454	20.46	20.47	7.82	7.83	7.84	7.86
Soybean oil		0.85	0.87	0.89	0.90	1.08	1.10	1.11	1.13
L-Lysine•HCL		0.26	0.26	0.26	0.26	0.69	0.69	0.69	0.69
DL-Methionine		0.01	0.01	0.01	0.01	0.14	0.14	0.14	0.14
L-Tryptophan		0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07
L-Threonine		0.02	0.02	0.02	0.02	0.21	0.21	0.21	0.21
Vitamins premix†		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Trace minerals premix¶		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Protease enzyme		0.000	0.025	0.050	0.075	0.000	0.025	0.050	0.075
Calcium carbonate		0.94	0.94	0.94	0.94	0.98	0.98	0.98	0.98
Dicalcium phosphate		0.77	0.77	0.77	0.77	0.87	0.87	0.87	0.87
Salt		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Total		100	100	100	100	100	100	100	100
Calculated analysis, %	Req.§								
ME, Mcal kg^{-1} MS	3.265	3.265	3.265	3.265	3.265	3.265	3.265	3.265	3.265
Crude protein	18.00	16.00	16.00	16.00	16.00	11.50	11.50	11.50	11.50
Calcium	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Available phosphorus	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Lysine	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Threonine	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Tryptophan	0.17	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.25	0.27	0.27	0.27	0.27	0.34	0.34	0.34	0.34
Arginine	0.37	0.95	0.95	0.95	0.95	0.59	0.59	0.59	0.59
Histidine	0.30	0.41	0.41	0.41	0.41	0.29	0.29	0.29	0.29
Isoleucine	0.51	0.69	0.69	0.69	0.69	0.48	0.48	0.48	0.48
Leucine	0.90	1.62	1.62	1.62	1.62	1.33	1.33	1.33	1.33
Valine	0.64	0.77	0.77	0.77	0.77	0.56	0.56	0.56	0.56
Methionine + Cystine	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Phenylalanine+Tyrosine	0.87	1.43	1.43	1.43	1.43	1.04	1.04	1.04	1.04
Determined analysis, %									
Gross energy, Mcal kg^{-1}		4.225	4.188	4.163	4.230	4.197	4.182	4.221	4.230
Crude protein		16.11	15.81	16.04	15.71	11.70	11.76	11.65	11.49
Calcium		0.68	0.74	0.68	0.79	0.79	0.80	0.71	0.78
Total phosphorus		0.52	0.53	0.54	0.61	0.53	0.54	0.52	0.55
Cost of diet ($/kg)Φ		0.229	0.23	0.23	0.23	0.233	0.233	0.234	0.234

[1]Control diet, †Provided per kg of diet (as fed basis): vit. A, 15,000 IU ; vit. D_3, 2,500 IU; vit. E, 37.5 IU; vit K, 2.5 mg; thiamin, 2.25 mg; riboflavin, 6.25 mg; niacin, 50 mg; B_6, 2.5 mg; B_{12}, 0.0375 mg; biotin, 0.13 mg; choline, 563 mg; pantothenic acid, 20 mg; folacin, 1.25 mg, ¶Provided per kg of diet (as fed basis): Fe, 150 mg; Zn, 150 mg; Mn, 150 mg; Cu, 10 mg; Se, 0.15 mg; I, 0.9 mg; Cr, 0.2 mg, §Nutrient requirements for growing pigs, NRC[2], Φcalculated cost with the price of ingredients at january-february 2006. Conversion to USD at the rate exchange (11.00 mexican pesos by 1 USD) of october 10, 2006

research[11], where the first level (16%) was the control diet and the second was the level with the lowest plasma urea nitrogen concentration in pigs. The diets were isoenergetics (3.265 Mcal ME kg^{-1}) and were added with crystalline amino acids to equal the total concentration of lysine, methionine, threonine and tryptophan as in the control diet; this control diet was formulated to meet the NRC[2] requirements for growing pigs. The weight and the feed intake of each pig was recorded weekly, in order to estimate weekly the Average Daily Gain (ADG), the Average Daily Feed Intake (ADFI) and the Feed: Gain Ratio (FGR) for each pig. The first and the last d of the experimental period, the backfat thickness and the longissimus muscle area were measured with a real time ultrasound (Sonovet 600; Medison, Inc., Cipress, California, USA), and, together with the initial and final body weight were used to determine the fat free lean gain (FFLG) and the Lean Meat Percentage (LMP) with the NPPC[12] equation. The last day of the experimental period blood samples were taken from the vena cava with vacutainer heparinised tubes (BD Vacutainer, Franklin Lakes, NJ, 07417, USA), put in ice until they were centrifuged at 2500 rpm (1286 g), then the supernatant was transferred to polyuretane tubes and freezed at -20°C until the determination of plasma urea nitrogen concentration by UV espectrophotometry[13] in the laboratory. The feed samples were ground in a Wiley mill with 1 mm screene and the following analyses were performed: N concentration with the Kjeldahl method[14]; gross energy with an adiabatic calorimetric Parr[14] bomb; Ca and P[15]. The data of variables measured weekly were analysed with the mixed procedure of SAS[16] to determine the fixed effect of time (week), block and treatment on ADG, ADFI and FGR. The means of these variables were obtained with the lsmeans procedure and compared with the Tukey test. The other variables were analysed with the GLM procedure and compared with the Tukey test[16].

Table 2: Composition of experimental diets for finishing pigs (experiment 2)

		Tratamiento							
Ingredient, %		T1[1]	T2	T3	T4	T5	T6	T7	T8
Sorghum		82.95	82.90	82.85	82.79	94.40	94.34	94.29	94.24
Soybean meal, 44%		14.47	14.48	14.50	14.51	1.85	1.86	1.87	1.89
Soybean oil		0.41	0.42	0.44	0.46	0.63	0.65	0.67	0.68
L-Lysine•HCl		0.20	0.20	0.20	0.20	0.63	0.63	0.63	0.63
DL-Methionine		0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13
L-Tryptophan		0.00	0.00	0.00	0.00	0.07	0.07	0.07	0.07
L-Threonine		0.003	0.002	0.002	0.002	0.19	0.19	0.19	0.19
Vitamins premix†		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Trace minerals premix¶		0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Protease		0.000	0.025	0.050	0.075	0.000	0.025	0.050	0.075
Calcium carbonate		0.81	0.81	0.81	0.81	0.86	0.86	0.86	0.86
Dicalcium phosphate		0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70
Salt		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis, %	Req.§								
ME Mcal kg^{-1} DM	3.265	3.265	3.265	3.265	3.265	3.265	3.265	3.265	3.265
Crude protein	15.50	14.00	14.00	14.00	14.00	9.50	9.50	9.50	9.50
Calcium	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Available phosphorus	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Lysine	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Threonine	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Tryptophan	0.14	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Methionine	0.20	0.23	0.23	0.23	0.23	0.30	0.30	0.30	0.30
Arginine	0.27	0.78	0.78	0.78	0.78	0.42	0.42	0.42	0.42
Histidine	0.24	0.36	0.36	0.36	0.36	0.24	0.24	0.24	0.24
Isoleucine	0.42	0.59	0.59	0.59	0.59	0.39	0.39	0.39	0.39
Leucine	0.71	1.50	1.50	1.50	1.50	1.21	1.21	1.21	1.21
Valine	0.52	0.68	0.68	0.68	0.68	0.47	0.47	0.47	0.47
Methionine + Cystine	0.44	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
Phenylalanine+Tyrosine	0.70	1.26	1.26	1.26	1.26	0.86	0.86	0.86	0.86
Determined analysis, %									
Gross energy Mcal kg^{-1}		4.185	4.122	4.273	4.190	4.187	4.247	4.151	4.214
Crude protein		14.18	14.47	14.42	14.38	9.64	9.71	9.46	9.61
Calcium		0.67	0.53	0.64	0.58	0.53	0.55	0.61	0.59
Total phosphorus		0.47	0.45	0.46	0.49	0.46	0.47	0.47	0.45
Cost of diet ($/kg)Φ		0.21	0.21	0.211	0.211	0.212	0.213	0.213	0.214

[1]Control diet, † Provided per kg of diet (as fed basis): vit. A, 120,000 IU; vit. D_3, 2,000 IU; vit. E, 30 IU; vit K, 2.0 mg; thiamin, 1.8 mg; riboflavin, 5.0 mg; niacin, 40.0 mg; B_6, 2.0 mg; B_{12}, 0.03 mg; biotin, 0.1 mg; choline, 450 mg; pantothenic acid, 16.0 mg; folacin, 1.0 mg, ¶Provided per kg of diet (as fed basis): Fe, 150 mg; Zn, 150 mg; Mn, 150 mg; Cu, 10 mg; Se, 0.15 mg; I, 0.9 mg; Cr, 0.2 mg, §Nutrients requirement for finishing pigs, NRC[2]. ΦCost of diets calculated with the price of ingredients at january-february, 2006. Conversion to USD at the rate exchange (11.00 mexican pesos by 1 USD) of october 10, 2006

Experiment 2: This experiment was conducted in the same Experimental Unit as experiment 1. Thirty two pigs crossbred (Yorkshire×Duroc×Pietrain) finishing (56.77±5.38 kg initial weight) barrows were randomly alloted into single (1.2×1.5 m) concrete floor pens equipped with a feeder and a niple waterer, in a completely randomized design in a factorial 2×4 arrangement (two CP% levels: 14 and 9.5%; four protease levels: 0.00, 0.25, 0.50 and 0.75 kg t^{-1}). There were eight treatments (T) with four replicates each. The dietary treatments Table 2 were formulated with sorghum-soybean meal and were as follows: T1) 14.0 and 0.00, control; T2) 14.0 and 0.25; T3) 14.0 and 0.50; T4) 14.0 and 0.75; T5) 9.5 and 0.00; T6) 9.5 and 0.25; T7) 9.5 and 0.50; and T8) 9.5 and 0.75, respectively. The diets were isoenergetic (3.265 Mcal ME kg^{-1}) and the low-protein diets were supplemented with crystalline L-lysine•HCl, L-threonine, DL-methionine and L-tryptophan to equal the level of these amino acids in the control (T1) diet. The data were obtained and analysed as in experiment 1, except that the initial weight was used as a covariate for the statistical analysis of all variables.

RESULTS

Experiment 1: There was no effect of CP level ($p>0.05$) nor enzyme addition ($p>0.05$) on ADG, ADFI, FGR, FFLG, BT, LMA and LMP Table 3. The plasma urea nitrogen concentration was reduced ($p\leq0.01$) in 62.12% as CP was reduced in the diet from 16 to 11.5%. The dietary level of protease did not affect PUN concentration ($p>0.05$). However, the interaction between the main factors analysed tended to have a significant effect on FFLG ($p\leq0.08$) and PUN ($p\leq0.09$). The fixed effects test indicated that time (week) had a significant effect on ADG, ADFI ($p\leq0.01$) and FGR ($p\leq0.02$).

Experiment 2: There was no effect of interaction between CP level and enzyme supplementation ($p>0.05$) on ADG, ADFI, FGR, FFLG, BT, LMA and LMP. The reduction of CP reduced ADG ($p\leq0.01$) by 10.1% and FFLG ($p\leq0.04$) by 94.27 g and increased FGR ($p\leq0.06$) by 6%. In addition, PUN concentration was reduced by 66.04% in pigs fed low-protein diet. The enzyme supplementation tended to increase PUN concentration ($p\leq0.08$) as more enzyme was

Table 3: Growth performance, carcass characteristics and plasma urea nitrogen concentration of growing pigs fed two crude protein levels and four protease levels (experiment 1)*

			Variable							
Treatment	CP	Protease	ADG¶(g d^{-1})	ADFI¶(kg d^{-1})	FGR¶	FFLG+(g d^{-1})	BT+(cm)	LMA+(cm^2)	LM%+	UREA+ (mg dL^{-1})
1	16.0	0.00	821	1.95	2.49	292	0.57	16.14	39.29	22.35^{a}
2	16.0	0.25	818	1.93	2.41	291	0.55	15.34	38.84	14.17^{a}
3	16.0	0.50	764	1.88	2.55	274	0.57	14.82	38.72	20.37^{a}
4	16.0	0.75	692	1.68	2.96	230	0.57	13.88	38.41	12.91^{a}
5	11.5	0.00	682	1.81	2.90	234	0.55	14.81	39.46	5.74^{b}
6	11.5	0.25	717	1.95	2.79	243	0.62	15.06	38.77	8.50^{b}
7	11.5	0.50	714	1.88	2.88	247	0.52	14.94	39.32	5.95^{b}
8	11.5	0.75	778	2.03	2.64	274	0.57	14.67	38.30	6.26^{b}
SEM			0.049	0.152	0.229	10.121	0.026	0.771	0.320	1.239
Main Effects										
CP	16.0		774	1.86	2.60	272	0.57	15.05	38.82	17.451^{a}
	11.5		723	1.92	2.80	250	0.57	14.87	38.96	6.614^{b}
Protease		0.00	751	1.88	2.70	263	0.56	15.47	39.38	14.05
		0.25	767	1.94	2.60	267	0.59	15.20	39.02	11.33
		0.50	739	1.88	2.72	260	0.55	14.88	38.81	13.16
		0.75	735	1.85	2.80	252	0.57	14.28	38.36	9.59
Week										
1			637^{b}	1.74^{b}	2.79^{ab}					
2			823^{a}	1.86^{b}	2.29^{b}					
3			628^{b}	1.83^{b}	3.32^{a}					
4			904^{a}	2.12^{a}	2.42^{b}					
Source of variation Pr > F values										
CP		0.16	0.59	0.23	0.14	1.00	0.87	0.75	0.01	
Protease		0.91	0.95	0.86	0.89	0.90	0.88	0.46	0.31	
CP×Protease			0.14	0.45	0.35	0.08	0.67	0.92	0.94	0.09
Week		0.01	0.01	0.02						

Fixed effects test

Variable	Source	DFN	DFD	F type III	Pr>F
ADFI	Week	3	45.5	15.61	0.01
FGR	Week	3	55.0	7.75	0.02
ADG	Week	3	50.7	16.04	0.01

[a, b]Different superscripts in the same column means significant difference ($p<0.05$), *CP = crude protein, SEM = standard error of the mean, ADG = average daily gain, ADFI = average daily feed intake, FGR = feed:gain ratio, FFLG = fat free lean gain, BT = backfat thickness, LMA = *longissimus* muscle area, LM% = lean meat percentage; UREA = plasma urea nitrogen concentration, DFN = degree of freedom numerator, DFD= degree of freedom denominator, ¶Variables analyised with PROC MIXED of SAS, +Variables analysed with PROC GLM of SAS

Table 4: Growth performance, carcass characteristics and plasma urea nitrogen concentration of finishing pigs fed two crude protein levels and four protease level (experiment 2)*

			Variable							
Treatment	CP	Protease	ADG (g d^{-1})	ADFI (kg d^{-1})	FGR	FFLG (g d^{-1})	BT (cm)	LMA (cm^{2})	LM%	UREA (mg dL^{-1})
1	14.0	0.00	900	2.84	3.24	357	1.13	33.16	38.70	18.63^{a}
2	14.0	0.25	810	2.69	3.48	313	1.15	30.41	38.14	18.71^{a}
3	14.0	0.50	896	2.98	3.44	343	1.13	32.86	38.60	24.86^{a}
4	14.0	0.75	918	2.75	3.25	350	1.25	31.80	37.78	20.84^{a}
5	9.5	0.00	834	2.80	3.49	311	1.32	33.61	38.73	5.47^{b}
6	9.5	0.25	781	2.69	3.53	301	1.30	32.26	38.40	6.94^{b}
7	9.5	0.50	766	2.64	3.57	271	1.23	30.16	38.02	7.29^{b}
8	9.5	0.75	789	2.78	3.61	292	1.18	30.64	38.17	8.50^{b}
SEM	0.043	0.120	0.136	10.468	0.048	0.791	0.274	0.455		
Main effects										
CP	14.0		881^{a}	2.81	3.35	341^{a}	1.16	32.06	38.30	20.76^{a}
	9.5		792^{b}	2.72	3.55	294^{b}	1.26	31.67	38.33	7.05^{b}
Protease		0.00	867	2.82	3.36	334	1.23	33.38	38.72	12.05^{b}
		0.25	796	2.69	3.51	307	1.22	31.34	38.27	12.83^{b}
		0.50	831	2.81	3.51	307	1.18	31.51	38.31	16.08^{a}
		0.75	854	2.76	3.43	321	1.22	31.22	37.98	14.67^{a}
Week										
1			802^{b}	2.86^{a}	3.59^{b}					
2			981^{a}	2.91^{a}	3.03^{b}					
3			835^{b}	2.88^{a}	3.63^{a}					
4			882^{ab}	2.71^{a}	3.15^{b}					
5			785^{b}	2.74^{ab}	3.61^{b}					
6			736^{b}	2.52^{c}	3.70^{b}					
Sources of variation Pr > F values										
IW^{and}			0.04	0.06	0.90	0.11	0.21	0.02	0.76	0.23
CP			0.01	0.31	0.06	0.04	0.17	0.73	0.95	0.01
Protease			0.39	0.69	0.66	0.52	0.97	0.49	0.61	0.08
CP×Protease		0.58	0.39	0.68	0.53	0.52	0.52	0.82	0.02	
Week		0.05	0.07	0.03						

Fixed effects test

Variable	Source	DFN	DFD	F type III	Pr>F
ADFI	Week	5	69.6	3.47	0.07
ADFI	IW	1	36.3	14.23	0.06
FGR	Week	5	74.6	3.93	0.03
ADG	IW	1	25.3	4.44	0.05
ADG	CP	1	22.2	7.86	0.01
ADG	Week	5	69.4	5.07	0.05

^{a,b,c}Different superscripts in the same column means significant difference (p<0.05), * CP = crude protein, SEM = standard error of the mean, ADG = average daily gain, ADFI = average daily feed intake, FGR = feed:gain ratio, FFLG = fat free lean gain, BT = backfat thickness, LMA = longissimus muscle area, LM% = lean meat percentage, UREA = plasma urea nitrogen concentration, SEM = standard error of the mean, IW = initial body weight, DFN = degree of freedom numerator, DFD = degree of freedom denominator, ^{and}The initial weight was used as a covariate for the statistical analysis of all variables

added in the diet. However, the interaction of CP×enzyme affected PUN concentration (p≤0.02), that was reduced as CP was lower in the diet, but increased in low-protein diets as the level of protease increased. The fixed effects test showed that time (week) had a fixed effect on ADG (p≤0.05), ADFI (p≤0.07) and FGR (p≤0.03), all variables increasing with time; also, CP had a fixed effect on ADG (p≤0.01), reducing ADG as CP was reduced in the diet. In addition, the initial weight had a fixed effect on ADFI (p≤0.06) and ADG (p≤0.05) Table 4.

DISCUSSION

Experiment 1: The results found in this experiment indicated that reducing CP by 4.5% units (from 16 to 11.5%) and supplementing with a protease in sorghum-soybean meal diet, pigs fed these diets did not improve growth performance, compared to pigs fed control, standard diet (16% CP). These results are similar to other research[17] where pigs were fed 3.6% less CP. In other findings, the pig response was consistent when they were fed corn-soybean meal or sorghum-soybean meal diets with 16 or 12% CP[4], or 16 or 12.5% CP[18], respectively. On the other hand, when a diet containing 11.5% CP was fed to pigs, a similar growth performance was found as the one obtanined in this experiment[19]. However, a higher reduction of CP in corn-soybean meal diet (from 17 to 11%) or sorghum-soybean meal diet (from 16.5 to 10.5%), an improvement of the growth performance was reported for growing pigs[7,20]. These results indicated that, in spite of the crystalline amino acid supplementation of lysine, methionine, threonine and tryptophan, to equal their concentration as in control diet, this reduction of CP may produce a deficiency of other essential AA, such as histidine, isoleucine and valine, with a negative impact on growth of the pigs[18,21,22].

The carcass characteristics did not change when pigs were fed any of the dietary treatments. Similar results were found with the same type of diets[23]. The values in the backfat thickness and the LMA were similar in all pigs in this experiment and also similar to other report where a 11% CP diet was fed to pigs; although in other case the BT tended to increase[24,25] and the LMA was reduced[25,18] as CP was lowered in the diet. In this experiment, a reduction of PUN concentration was found in pigs fed low-protein diet, which is consistent with other reports where similar diets were used[2,8,18,25,26], although different with other findings[7]. The reduction of PUN indicated a better efficiency of nitrogen utilization when there is not an AA imbalance and crystalline AA are added to diet[22,27,28].

Experiment 2: The results of this experiment indicated that pigs fed low-protein (9.5%) diets resulted in less growth rate and lower FFLG, which is consistent with other reports[25,29], concluding that the reduction of 4% units implied AA or other nutrients defficiency, affecting the normal growth of pigs[7,18]. In spite of the similar feed intake, pigs fed low-protein diets showed lower FFLG, which disagree with other research where the same type of diets were used[23]. The reduction of CP in finishing pig diets, a reduction of limiting AA was observed, especially valine, histidine and isoleucine; this reduction may affect the growth performance of pigs, although the carcass characteristics were not affected, in agreement with previous reports[23,30]; that means that pigs fed low-protein diets had similar backfat thickness as in pigs fed standard CP diet. This results do not agree with others where higher adiposity has been observed in pigs fed low-protein diets[25,18]. The similar LMP and LMA found in pigs fed low-protein or standard CP diet were reported by other researchers[4,23]. On the other hand, the reduction of PUN concentration confirmed the trend observed in other research[23,26]. When CP is reduced in the diet, there is a higher efficiency of AA utilization by pigs[4,23], even when other essential AA are defficient compared to requirements.

CONCLUSION

The addition of exogenous protease to standard sorghum-soybean meal, or to low-protein, sorghum-soybean, amino acid-supplemented diets did not improve the growth performance and carcass characteristics of growing-finishing pigs. There may be other factors in the ingredients and/or in diets preventing pigs to express their maximum genetic potential for growth.

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