Interest of using synthetic amino acids, including L-Valine for formulating low crude protein pig diets based on rapeseed meal

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Abstract
One hundred forty-four group-housed growing-finishing pigs were allocated to one of the three experimental feeding strategies. Diets S were formulated with soybean meal and their dietary crude protein (CP) content averaged 15.9 and 15.0%, respectively during the growing and the finishing periods. In diets R, CP levels were reduced at 15.0 and 14.1%, respectively, and soybean meal was replaced partially or completely by rapeseed meal and balanced with L-Lysine, DL-Methionine, L-Threonine and L-Tryptophan. In diets RV, L-Valine was also incorporated (0.3 g/kg) allowing an additional reduction of CP content (14.5% and 13.2%, respectively). All diets were formulated on the same net energy basis (9.7 MJ NE/kg) and on minimum ratios between digestible lysine and other amino acids following the ideal protein profile. Over the 27-111 kg BW range, no significant differences were observed between treatments on average daily gain, feed intake, feed conversion ratio or carcass fatness. These results indicate that it is possible to replace soybean meal by rapeseed meal in association with available free amino acids for a long time without any consequence on growth performance. They also show that an additional reduction of dietary CP content can be achieved with L-Valine utilisation without any consequence on growth performance, when diets are formulated on the NE basis and in agreement with the ideal protein concept. Reduced dietary CP performed through the R and RV strategies were associated with a reduction of N output by 400 and 650 g /pig, respectively.

Introduction
Rapeseed meal produced from low erucic acid and glucosinolates varieties (i.e., 00 rapeseed) is a feedstuff produced locally in numerous European countries. Taking into account the increased production of biofuel, available amounts of rapeseed meal are presently increasing. Its nutritional values are well known, thus this feedstuff can apply as a solution toward a reduction of soybean meal utilization in pig diets. When incorporation rates of protein sources are reduced, dietary amino acid balance is often adjusted to the ideal protein profile through incorporation of crystalline amino acids in the formula. Incorporation of L-Valine, in addition to L-Lysine, L-Threonine, L-Tryptophan and DL-Methionine can help to design diets toward much more lower soybean meal incorporation rate and more generally to reduce the crude protein level without impairing the amino acid balance. The present trial was carried in order to evaluate the rapeseed meal utilization, as an alternative to soybean meal incorporation in pig diets, in association with a concomitant reduction of the dietary crude protein content.

Material and methods
The trial was performed with 144 crossbred gilts and barrows in the IFIP experimental unit located at Villefranche de Rouergue (Aveyron, France). Pigs from the two genders were bred separately and group-housed (6 per pen) during the fattening period. They were allocated to one of the eight replicates of six pens each (3 treatments × 2 genders). Thereafter, the pens within each replicate were allocated to one of the treatments. Within each treatment, two diets were formulated corresponding to the 27-65 kg (growing phase) and the 65-111 BW ranges (finishing phase). Diets were formulated with soybean meal (without rapeseed meal nor L-Valine) in treatment S; with rapeseed meal but no L-Valine in treatment R, and with rapeseed meal and L-Valine in treatment RV (Table 1). The incorporation rates of wheat and barley were modulated among experimental treatment in order to obtain iso-energy diets (9,7 MJ NE/kg). Bicalcium phosphorus was used in order to obtain 2.8 and 2.3 g digestible phosphorus per kg during the growing and the finishing phases, respectively. The following minimum ratio between the ileal standardised digestible lysine (LYSd) and other essential amino acid were used: methionine: 30%, methionine + cystine: 60%, threonine: 65%, tryptophane:

20%, valine: 70%, isoleucine: 55%, leucine: 100%, histidine32%, and the ratio between digestible tryptophane and digestible large neutral amino acids was at least 5%.

Experimental diets were sampled periodically in order to check in the accordance with the formula. The pigs were weighed individually every two or three weeks after 16h fasting. The cumulated feed intake per pen was measured between two BW recording in order to calculate the average daily feed intake (ADFI). Pigs were slaughtered in a commercial slaughterhouse in three groups every seven days depending on the time they reached the minimum expected slaughter weight (i.e., 107 kg). At slaughter, backfat (G34) and muscle (M34) thicknesses between the 3^{rd} and 4^{th} last ribs were measured and used to calculate the carcass lean content: 62,19 - 0,729 G34 + 0,144 M34.

***Table 1** : Nutritional characteristics of the experimental diets.*

Stage	**Growing phase**			**Finishing phase**		
Diet	**S**	**R**	**RV**	**S**	**R**	**RV**
Barley	517	256	277	629	300	470
Wheat	289	564	556	200	540.4	396.7
Soybean meal 46	161	50.6	28.5	144.5	0	0
Rapeseed meal	0	95	103	0	132	104
L -Lysine HCl	2.7	4.5	5.0	1.9	4.1	4.5
DL-Methionine	0.4	0.4	0.4	0.2	0.2	0.3
L-Threonine	0.8	1.4	1.6	0.5	1	1.3
L Tryptophan	0	0.2	0.3	0	0.2	0.2
L-Valine	0	0	0.3	0	0	0.3
Salt	3.5	3.5	3.5	3.5	3.5	3.5
Dicalcium phosphate	4.8	3.9	3.9	0.7	0	0
Limestone	12.9	12.6	12.6	11.8	10.7	11.3
Rapeseed oil	5.0	5.0	5.0	5.0	5.0	5.0
Vitamin and trace mineral mixture and phytases	2.9	2.9	2.9	2.9	2.9	2.9
Nutritional values[1]						
Dry mater, g	880 *889*	874 *879*	875 *880*	882 *889*	873 *881*	876 *885*
Crude fibre Weende, g	33	38	39	35	40	41
Starch, g	449 *465*	477 *487*	483 *487*	455 *457*	486 *477*	490 *495*
Ashes, g	50 *47*	46 *41*	46 *43*	45 *44*	41 *38*	41 *37*
Calcium, g	7.4	7.5	7.5	5.9	5.9	5.9
Phosphorus (P), g	4.6	4.8	4.8	3.9	4.3	4.1
Digestible P (as mash), g	2.8	2.8	2.8	2.3	2.4	2.3
Ether extract, g	22 *22*	21 *21*	21 *22*	22 *23*	21 *22*	22 *23*
Crude protein, g	159 *162*	150 *149*	145 *149*	150 *158*	141 *146*	132 *139*
Digestible protein, g	132	122	117	123	111	103
Lysine, g	9.4 *9.1*	9.4 *9.2*	9.4 *9.6*	8.4 *8.5*	8.5 *8.4*	8.4 *8,6*
Digestible amino acids						
Lysine, (LYSd), g	8.3	8.3	8.3	7.3	7.3	7.3
Methionine, % LYSd	31	31	30	31	32	31
Met+cystine, % LYSd	62	65	64	65	71	66
Threonine, % LYSd	65	66	66	66	65	65
Tryptophan, % LYSd	20	20	21	21	22	20
Isoleucine, % LYSd	67	58	55	71	59	54
Valine, % LYSd	78	70	70	84	74	73
Leucine, % LYSd	116	105	100	125	110	101
Histidine, % LYSd	40	37	35	43	39	35
Digestible energy, kcal	3240	3184	3169	3232	3168	3157
Net energy (NE), MJ	9.7	9.7	9.7	9.7	9.7	9.7
LYSd / NE, g/MJ	0.85	0.85	0.85	0.75	0.75	0.75

1. Normal character: expected value, italic character: result of the chemical analyses.

Data were submitted to an analysis of variance with the treatment (T, n=3), the gender (G, n=2), the interaction between T and G and the replicate as the main effects (proc GLM, SAS, version 8.02, SAS Institute Inc., USA). Individual data were analysed with the pen as the experimental unit. Average growth performance per gender and treatment were used in order to parameterize growth profiles under the InraPorc® software and to assess the N and P output per pig.

Results and discussion

No significant interaction was observed between the treatment and the gender on growth performance or carcass characteristics (Table 2). Neither the AGD, FCR nor carcass leanness were influenced by the treatment.

A lower N intake was observed with diets R and RV (-7 and -11% than with diets S, respectively). However, this reduction did not compensate for the lower N digestibility for diets R and RV that resulted from the lower crude protein digestibility from rapeseed meal. Therefore the faecal N output was increased with these two later diets (+7 and +6%, respectively).

Table 2: Growth performance over the 27 to 111 kg body weight range and carcass characteristics.

	Treatment						Statistics			
	R		RV		S		RSD	T	G	R
N. obs	47		48		47					
Body weight, kg[1]										
Initial	27.4		27.5		27.4		0.5			***
Transition	65		65		65		3		***	*
Slaughter	111		111		111		3			
Fattening duration, j[1]										
Before transition	←		42		→					
Before slaughter	105		105		103		5	T×G**	***	***
ADG, g/d[1]	801		801		818		52		***	
Growing phase	897		900		900		58		***	***
Finishing phase	738		735		763		59		*	
N. pens	8		8		8					
ADFI, kg/d[2]	2.34		2.38		2.33		0.10		***	
Growing phase	2.15^{a}		2.18^{a}		2.07^{b}		0.07	*	***	
Finishing phase	2.46		2.51		2.51		0.13		***	
IC, kg/kg[2]	2.94		2.97		2.87		0.10			
Growing phase	2.39		2.42		2.33		0.09			
Finishing phase	3.38		3.43		3.31		0.14			
Carcass, kg[1]	90.9		91.3		91.4		2.9			
Dressing percentage[3]	81.8		82.0		82.0		1.2			
Backfat G34, mm[3]	13		14		13		3		***	
Muscle M34, mm[3]	62		62		63		4			
Carcass leanness, %[3]	61.3		60.9		61.8		2.0		***	
Nitrogen, kg/pig[4]										
Intake	6,06	*(100)*	5,65	*(93)*	5,40	*(89)*				
Retained	2,03	*(100)*	2,02	*(99)*	2,03	*(100)*				
Output	4,03	*(100)*	3,63	*(90)*	3,37	*(84)*				
in faeces	1,07	*(100)*	1,15	*(107)*	1,13	*(106)*				
in urine	2,96	*(100)*	2,49	*(84)*	1,24	*(76)*				
Phosphorus, g/pig[4]										
Intake	1,03	*(100)*	1,10	*(107)*	1,08	*(105)*				
Retained	0,43	*(100)*	0,42	*(100)*	0,43	*(100)*				
Output	0,60	*(100)*	0,67	*(112)*	0,65	*(108)*				
in faeces	0,41	*(100)*	0,47	*(115)*	0,46	*(112)*				
in urine	0,19	*(100)*	0,20	*(106)*	0,19	*(100)*				

1. Model 1: split-plot variance analysis with the treatment (T, n=3), gender (G, n=2), interaction TxG and replicate (R,=8) as main effects. The pen was considered as the experimental unit.

2. Model 2: variance analysis from average data per pen with T, G, TxG and R as the main effects.

3. Model 3: the slaughter body weight was introduced as a covariate in the statistical model 1.

4. Assessed using InraPorc software.

In spite of this, the overall N output was reduced by 10% with diets R and by 16% with diets RV because of the important reduction of urinary N output (-16 and -24%, respectively).

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As far as P was concerned, a higher P intake was observed in pigs fed the R and RV diets (+0.07 and +0.05 kg/pig for R and RV pigs, respectively). Such a result was due to the lower P digestibility from rapeseed meal, thereafter the extra P intake was excreted almost completely in faeces.

Conclusion

The current trial was performed with diets designed on the same NE basis and ratio between amino acids in agreement with the ideal protein concept. In such conditions, our results demonstrate that it was possible simultaneously to reduce the dietary CP content and to replace soybean meal by rapeseed meal and crystalline amino acids (L-Lysine, DL-Methionine, L-Threonine, L-Tryptophan, L-Valine) without any consequence on growth performance and carcass value. Subsequently, N output was considerably reduced. However, rapeseed meal incorporation was associated with higher P output, but to a lower extend when L-Valine is also used in order to decrease further the dietary CP content, i.e. the incorporation rate of protein sources. Depending on the environmental constraints on P output over the geographic area, such an effect may limit the incorporation rate of rapeseed meal in pig diets.

In our study it was not possible to get completely rid off soybean meal during the growing phase. With diets formulated on a lower NE basis or with another protein rich feedstuff, such as peas or horse bean, in association with rapeseed meal and crystalline amino acids, it would have been probably the case.

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