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Effects of increasing the farm produced content in organic feeds on pig performances.

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Abstract

In three experimental facilities (Exp.1, 2 and 3), two organic diets, one complex including processed feedstuffs as wheat bran and heat-treated soya beans (control), the other simplified and containing over 80 % of cereal and pulses (CP), were compared for growing-finishing pigs. The base components of the CP diets were moist maize grain, wheat and faba beans in Exp.1, triticale plus coloured-flowered peas in Exp.2, and triticale, oats, white-flowered peas and faba beans in Exp.3. The diets were formulated with similar energetic values and a lysine content (0.70 g ileal digestible lysine /MJ NE) 20 % lower than the conventional mean requirement for growing pigs. However, the CP diet had a lysine proportion 30% lower than requirement in Exp.1 and did not achieve the ideal protein pattern in Exp. 2 and 3. Diets were given in all experiments from 35 to 115 kg according to a feeding plan. Respectively 96, 100 and 80 pigs were used in Exp.1, 2 and 3 and were blocked in straw bedded pens of 4, 25 and 40.

In Exp.1, pigs receiving the control diet had a lower average feed intake than those offered the CP diet ($p<0.01$), whereas feed intake was similar between treatments for Exp.1 and Exp2. Daily weight gains (g/d) for pigs offered the control and the CP diets were respectively of 673 and 669 in Exp.1 ($p>0.05$), 760 and 719 in Exp.2 ($p=0.04$) and 684 and 677 in Exp.3 ($p>0.05$). The feed conversion rate (g/g) was high and reached respectively 3.28 and 3.41 in Exp.1 ($p=0.01$), 3.2 and 3.,4 in Exp.2, 3.3 and 3.4 in Exp.3. The lean meat rate did not differ significantly in Exp.1, 2 and 3, for pigs given control and CP diets. The study underlines that with a moderate growth objective, an organic feed with a low energetic and protein concentration can yield a satisfying lean meat rate. In spite of a tendency for lower performances, especially concerning the feed conversion rate, a simplified diet based on cereal and pulses can be used, taking into account its economical interest for organic pig production.

Keywords: pigs, organic, feed composition, cereals, pulses.

Introduction

The direct use in feeds of the farm's vegetal production is an important point to enhance the profitability of organic livestock production, and especially of swine production. The main problem is that this option, based on the incorporation of a limited number of raw materials, exacerbates the difficulty to achieve the nutritional balance of feeds for use in organic production. The ban on supplemental amino acids (AA) results in organic diets of unbalanced protein composition (Blair, 2007) and reduces the number of alternatives to processed feedstuffs as potato protein concentrates or heat-treated soya beans. Another issue is to establish the energy and AA requirements of organic pigs which may differ from those of conventional pig as a consequence of housing conditions and activity, with a wide range of genotypes of pigs (Jakobsen and Hermansen, 2001).

A study was conducted to assess the consequences of simplified and less well-balanced formulas on the growth and carcass performances of fattening pigs.

1. Materials and Methods

Three trials (Exp.1, 2 and 3) were performed in three French experimental facilities: Adæso-Maïz'Europ in Pau-Montardon, Chamber of Agriculture of Pays de Loire in Trinottières, and Ifip-Institut du porc in Romillé, respectively. In each of three experiments, a basal complex organic feed (control) was compared to a simplified diet containing over 80 % of cereal and pulses that could be produced on farm (CP).

1.1 Animals and housing.

In each farm, all pigs were reared in a similar way from birth to weaning. Piglets were born in non organic herds, indoor in Exp.1 and 3 and outdoor in Exp.2, and were weaned at 28 ± 1 days of age. After a post-weaning period until the average weight of 25 kg, they were used for the experiments during the fattening period (Figure 1). The designs were made as much as possible in accordance with the organic standards, although pigs were kept without access to an outdoor area and straw was used as roughage.

In Exp.1, ninety-six pigs of both sexes and issued of a 3-way maternal line (LWx(LDxD)) and a LWxP paternal line were introduced in the fattening unit at an average body weight of 24.4 ± 0.8 kg. They were blocked on body weight and sex and allocated to 12 pens of 4 pigs for each sex, i.e. 24 pigs per treatment and sex. Pens were partly slatted and small quantities of linseed straw were distributed. The pigs were reared during winter (from October to February) in a naturally ventilated atmosphere and received, if necessary, homeopathic treatments. The feeds were distributed as meal and mixed with water at a dilution ratio of 1:1 (l/kg). They were provided twice a day in two similar portions.

In Exp.2, one hundred male and female pigs (LWxLD) x (LWxP), raised on straw bedding during post-weaning, were introduced at an average weight of 27.5 ± 3.0 kg in the fattening unit. They were blocked to 4 pens of 25 pigs, one by treatment and sex. Pigs were housed on deep straw litter in a barn with a slatted wood side but no external courtyard. The feeds were provided in dry feeders. The experiment took place fro July until November.

In Exp.3, eighty crossbred pigs (LWxLD) x (LWxP) reared in a straw bedding nursery, were blocked at an average weight of 25.2 ± 2.2 kg into 2 identical pens with an equal number of males and females in each pen. The building was deep-bedded with straw, opened on one side with a wood cladding and a windbreak curtain, without external courtyard. Animals were fed using in each pen, 3 wet-dry feeders with integrated water dispenser to moisten the feed. The experiment began in June and finished in October.

1.2 Feeds

During post-weaning, pigs received firstly a phase 1 diet and after that an organic phase 2 diet. When being housed in the fattening unit, they continued to be fed with the same phase 2 diet up to 35 kg body weight. An identical phase 2 organic feed was used for all trials. The ingredient composition of this commercial feed was not available. However, it contained barley, triticale, wheat, corn, yeasts, extruded and toasted soybeans, faba beans, expeller soybean and sunflower meals, wheat bran, clay, sugar molasses, minerals and vitamins. It provided 9.1 MJ net energy /kg, 182 g crude protein/kg and 1.1 g total lysine /MJ of net energy. These characteristics were lower than the usual AA requirements estimated in the tables (ITP et al., 2002) for young pigs from 12 to 25 kg but met the requirements of growing pigs above 25 kg body weight.

From 35 kg to slaughtering, a one-phase growing-finishing diet was used for the whole experimental phase. The ingredient composition of the diets given in each experiment is presented in Table 1. All raw materials used in the experimental diets were issued from organic farming. The nutrient values given for each ingredient in the French composition tables (INRA-AFZ, 2004) were used in order to formulate the feeds.

The same control feed was established for the three experiments. This control diet was relatively complex and contained corn, wheat, wheat bran, faba beans, processed full-fat soybeans, brewer's yeasts and dehydrated alfalfa as base components. In Exp.2 and 3 control diets, wheat (24.4%) was substituted by triticale (20.2%) and barley (4.2%).

In Exp.1, high moisture maize grains stored in one hermetic silo were used as main cereal (50%) and 20 % faba beans as source of protein of the experimental CP diet (CP1).

Figure 1 – Experimental design of Exp.1, 2 and 3

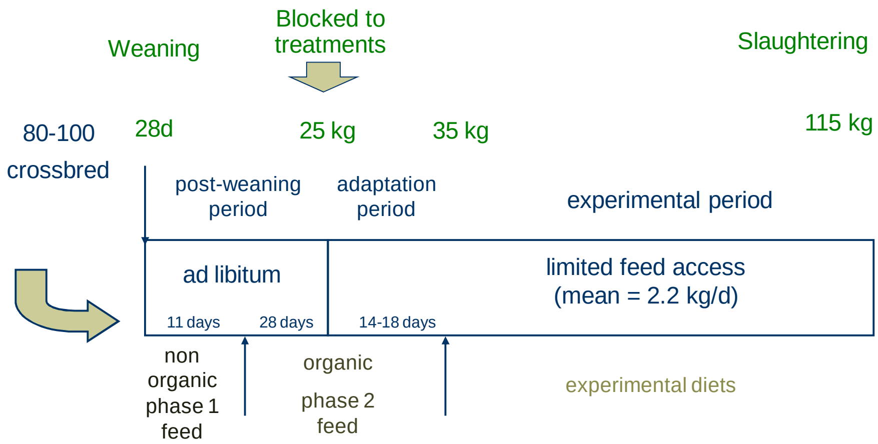


Table 1 – Ingredient composition of control and CP feeds in Exp.1, 2 and 3 (percentage as fed basis)

	Exp.1, 2, 3 control	Exp.1 CP1	Exp.2 CP2	Exp.3 CP3
corn	25.0	50.0(1)		
wheat	24.4(2)	10.7		
triticale			55.0	52.9
oats				10.2
barley				
wheat bran	17.5			
coloured flowered peas			28.0	
white flowered peas				7.1
faba beans	13.0	20.0		18.4
heat-treated soybeans	9.2			
brewer's yeast	4.6	7.0	7.0	8.2
alfalfa dehydrated	4.0	10.0	7.0	
premix(3)	2.3	2.3	3.0	3.2

(1) : high moisture maize grain.
(2) : substituted by 20.2% triticale and 4.2% barley in Exp.2 and 3 control feeds.
(3) : salt, limestone, vitamins, trace elements

Table 2 – Calculated and analysed nutrient content of the diets in Exp.1, 2 and 3 (as fed basis, g/kg) (a)

	Exp.1		Exp.2		Exp.3	
	control	CP1	control (b)	CP2	control (b)	CP3
dry matter	875 (878)	843 (851)	876 (886)	885 (883)	(880)	879 (883)
crude protein	163 (159)	144 (140)	162 (164)	159 (158)	(162)	159 (155)
total lysine	8.1 (8.2)	7.2 (7.4)	8.3 (8.7)	9.0 (8.5)	(8.5)	8.9 (8.4)
ileal dig lysine	6.4	5.6	6.6	*6.5* (c)		7.1
crude fibre	55 (55)	58 (58)	56 (52)	53 (52)	(51)	47 (53)
fat	40 (38)	24 (23)	40 (32)	15 (14)	(32)	19 (17)
starch	393 (381)	446 (466)	388 (431)	442 (441)	(443)	448 (449)
ash	53 (50)	50 (39)	54 (57)	60 (59)	(52)	54 (52)
dig energy (kcal)	3051	3014	3029	3051		3082
net energy (MJ)	9.1	9.1	9.1	9.1		9.2
totLys /DE (g/1000kc)	2.6	2.4	2.7	2.9		2.9
digLys /EN (g/MJ)	0.70	0.62	0.73	0.72		0.77
dMet (% dLys)	30	29	29	*[24]* (e)		24
dMet+dCys (% dLys)	64	59	63	*[54]* (e)		54
dThr (% dLys)	71	73	69	*[67]* (e)		63
dTry (d) (% dLys)	20	16	19	*[19]* (e)		18

a : in parenthesis the analysed content of specific nutrient is given.
b : the same control feed was used in Exp.2 and 3
c : calculated on a estimated basis of 70% ileal digestibility for *Assas* pea lysine
d : calculated on an estimated value of alfalfa-meal for dTry
e : as digestible amino acids content of *Assas* pea are not available, ratios to lysine are calculated on a total amino acids basis

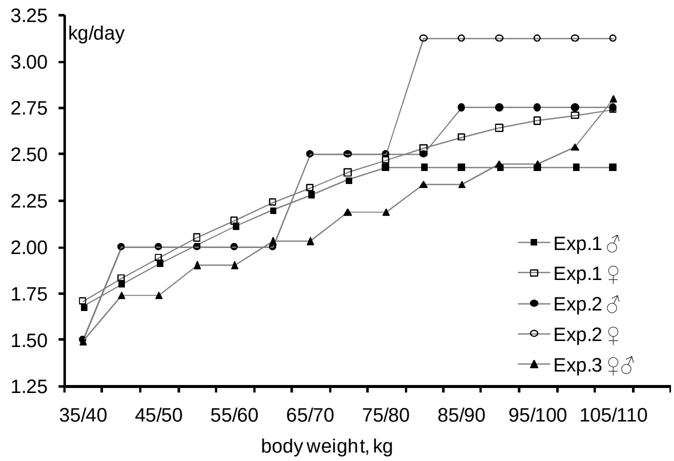
In Exp.2, main components of the cereal-pulses diet (CP2) were 55% triticale and 28% colored flowers peas (cv. *Assas*). While almost all peas with white flowers produced in Europe are varieties without tannins, *Assas* variety as well as others coloured flower peas (which are often grown in organic farming) contain tannins. In Exp.3, triticale was the energy source of the CP feed and about 25 % of pulses (white coloured peas and faba beans) were incorporated (CP3).

Alfalfa meal in Exp.1 and 2, and oats in Exp.3 substituted to wheat bran as fibre source and in order to limit the energy concentration of the CP diets. At last, to improve the AA balance of the CP diets, the brewer's yeasts inclusion was increased in replacement of heat-treated soybeans.

The nutritional content of the experimental diets is presented in Table 2. For all diets, the energy concentrations were intentionally limited to 9.1 MJ NE /kg in order to more easily achieve a proper balance for protein and energy. The standardized ileal digestible lysine contents of Control, CP2 and CP3 diets were of 0.7 g /MJ NE corresponding at a reduction about 20% of the usual supply for growing pigs (i.e. 0.9 g dlys / MJ NE; ITP et al., 2002) and about 10% of the one for finishing pigs (i.e. 0.8 g/MJ). For the CP1 diet of Exp.1, the digestible lysine value (0.62 g dlys /MJ NE) was 30 and 20 % lower than the standard level of growing and finishing needs, respectively. Because pulses are poor in methionine, it was additionally difficult to achieve the ideal protein pattern for the sulfur amino acids. Thus, with lower ratios to lysine than usually recommended, methionine as well as methionine + cystine were limiting AA in CP2 and CP3 diets.

In all experiments, feeds were given according to a restrictive feeding plan (Figure 2) in order to avoid an excessive fatness allowed by the low protein deposit. This plan was previously calculated to result in a 700 g/d average growth of fatteners.

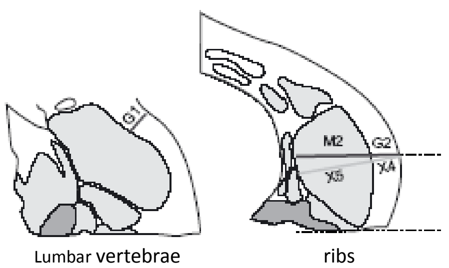
Figure 2 – Quantities of feed distributed to males and females in Exp.1, 2 and 3.



1.3 Measurements and statistical treatment

Pigs were individually weighed at the beginning of the fattening period, then at two weeks intervals. Feed intakes per pen were recorded daily during the trials. The pigs were slaughtered in two batches when individual pigs reached about 115 kg of body live weight. Carcass weight was estimated by multiplying by 0.975 the measured weight of the hot, eviscerated carcass 45 m after slaughter. The dressing percentage was calculated as carcass weight/ live weight ratio. Backfat (g1, g2) and muscle (m2) thickness were measured on two dorsal spots (figure 3). The lean meat percentage was calculated by a pig grading equation (TMP = 63.20 – 0.334g1 – 0.427g2 + 0.144m2; Daumas, 2008).

Figure 3 – Spots of backfat (g1, g2) and muscle (m2) depth measures (Daumas et al., 1999)



Fat depth G1 : fat depth between the 3rd and 4th last lumbar vertebrae, 8 cm off the midline, perpendicular to the rind.
Fat depth G2 : fat depth between the 3rd and 4th last ribs, 6 cm off, parallel to the midline.
Muscle depth M2 : muscle depth between the 3rd and 4th last ribs, 6 cm off, parallel to the midline.

Fattening and slaughtering performances were processed by analysis of variance with pig as the experimental unit (Proc GLM, SAS Institute). Data of Exp. 1 were analysed with a model that included effects of block, dietary treatment, sex, and interactions. Data of Exp. 2 were analysed with a model that included treatment, sex and interaction effects and initial live weight as a covariate. For carcass characteristics (except for carcass weight), live weight at slaughter was used as a covariate in each of the experiments. Feed intake and feed efficiency per pen have been analysed only in Exp.1 because the number of experimental units was not sufficient in the two other experiments. Means were compared using Tukey test. Only the effects of dietary treatments and sex are presented here.

2. Results

In general, the analysed composition of the diets agreed well with the calculated composition (Table 2). However, the analysed starch content of CP1 diet in Exp.1 was somewhat higher than calculated. Thus, the net energy value of this diet might have been better than predicted, resulting in probably lower than calculated AA to energy ratios.

There were no major health problems with the pigs in all experiments. 3 pigs (2 control and 1 CP1) in Exp.1, 6 pigs (3 by treatment) in Exp.2 and 5 pigs in Exp.3 (2 control and 3 CP3) died or were removed from test. The effects of dietary treatments on pig performances are presented for each experiment in Table 3.

2.1 Experiment 1

In Exp.1, the diets were distributed according to a progressive feeding plan. A limitation to 2.4 kg of the feeding level was applied for castrated males from the average weight of 75 kg (figure 2). Daily mean temperatures in the barn fluctuated between 17°C and 24°C among days. For each day, the maximal variation of the day was not higher than 5-7 °C.

Daily feed intakes (DFI) were similar during the growing period among sex and treatments. For both treatments, the experimental phase diets caused a decrease of growth so that average daily gains (ADG) during the growing period were lower than during the previous pre-experimental period. Although the differences were not significant, pigs offered the CP diet were 0.9 kg lighter (ns) and had a 3% lower ADG ($p = 0.2$) at the end of the growing phase. CP diet tended to increase the feed conversion ratio (FCR; +4%; $p = 0.2$).

Thus, in order to keep a same final weight, quantities of CP1 diet distributed to pigs had been increased from that moment. Consequently, during the finishing phase, pigs fed the CP1 diet received 3.7% feed more than pigs offered the control diet ($p < 0.01$). Females received also 5% feed more than barrows ($p < 0.01$). ADG in the finishing period was higher for females than for males (733 vs. 688 g/d; $p < 0.01$) but did not differ between treatments. Feed efficiency was similar among sexes but was degraded by 3.5% for the CP1 feed ($p = 0.05$).

For the whole experimental period, DFI (2.30 vs. 2.20 kg/d; $p < 0.01$) and ADG (684 vs. 658 g/d; $p < 0.01$) were higher for females than for males. The pigs fed with the CP1 diet received more feed (+3%; $p < 0.01$) and had a

Table 3 – Pre-experimental performances and effect of diet composition from 35 kg to slaughtering on growth performances of pigs during growing, finishing and overall experimental phases in Exp.1, 2 and 3 [a]

	Exp.1				Exp.2				Exp.3			
	control	CP2	rmse	sign. [d]	control	CP2	rmse	sign. [d]	control	CP3	rmse	sign.[d]
weight[a], kg												
Initial[c]	24.4	24.5	0.2	ns	27.7	27.3	0.8	S*** T* TxS**	25.2	25.2		S**
experimental[c]	36.1	35.9	1.1	ns	36.9	36.3	1.9	S**	35.5	34.9	1.2	T*
finishing phase	60.8	59.9	2.0	ns	66.5	65.0	4.7	S*	59.6	59.4	5.7	TxS*
final	116.1	115.9	2.3	ns	114.5	111.5	9.4	S***	117.4	116.7	12.3	ns
number days	119.0	119.0	3.9	ns	102.9	105.1	4.9	T*	121.2	122.0	10.5	ns
feed intake[b], kg/d												
pre-exp. [c]	1.47	1.46	0.06	S*	1.5 ±0.0	1.5 ±0.0			1.5	1.5		
growing	1.83	1.85	0.04	ns	1.9 ±0.0	1.9 ±0.0			1.7	1.7		
finishing	2.41	2.50	0.02	T* S*	2.7 ±0.1	2.8 ±0.1			2.4	2.4		
overall exp.	2.21	2.28	0.02	T* S*	2.4 ±0.1	2.4 ±0.1			2.1	2.1		
daily gain[a], g/d												
pre-exp. [c]	647	632	63	ns	654	641	131	ns	734	690	87	T*
growing	603	586	43	ns	705	684	87	ns	589	598	134	TxS*
finishing	709	711	27	S*	797	745	131	T^{t} S***	733	719	158	ns
overall exp.	673	669	21	S*	760	719	96	T* S***	684	677	123	ns
feed conversion[b], kg/kg												
pre-exp. [c]	2.30	2.31	0.19	ns	2.3 ±0.1	2.3 ±0.1			2.0	2.1		
growing	3.03	3.16	0.22	ns	2.7 ±0.1	2.8 ±0.0			3.2	3.2		
finishing	3.40	3.52	0.14	T*	3.5 ±0.2	3.7 ±0.2			3.3	3.4		
overall exp.	3.28	3.41	0.11	T*	3.2 ±0.1	3.4 ±0.1			3.3	3.4		

(a) Weight and daily gain values in the table are presented as least-square means and root mean square error (rmse) for 48 pigs per treatment in Exp.1, 50 pigs per treatment in Exp.2 and 40pigs per treatment in Exp.3.

(b) Data for feed intake and feed conversion are means of 12 pens of 4 pigs each in Exp.1, 2 pens of 25 pigs in Exp.2 and 1 pen of 40 pigs in Exp.3.

(c) Pigs were blocked at initial weight and were given dietary treatments from experimental weight. Pre-exp.: pre-experimental phase. Overall exp.: growing and finishing phases.

(d) From analysis of variance including the effects of dietary treatment (T), sex (S), and interaction (TxS). Statistical significance: *** P < .001, ** P < .01, * P < .05, t P < .10, ns (not significant) P > .05.

similar daily gain to pigs offered the control diet, but there was a 4% increase in FCR (p = 0.01) during the experimental period.

Number of days to achieve the slaughter weight was not influenced by the dietary treatment, but it needed 3.5 days more for males than for females (p = 0.06). Carcass weight and dressing percentage were similar among treatments and sexes. In spite of the feeding limitation applied more early for castrated males, the g2 (14.7 vs. 11.7 mm; p < 0.01) fat depth was significantly higher for castrated than for females. An interaction (p < 0.01) between the sex and treatment effects on the g1 fat depth occurred. This interaction resulted of CP males having a thinner g1 depth than control males (16.2 vs. 17.8 mm), whereas CP females had a higher g1 depth than control females (15.8 vs. 14.8 mm). When averaging g1 results, there was only a main effect of sex (17.0 vs. 15.3 mm for males and females, respectively; p < 0.01). Muscle depth was lower for barrows (54.7 vs. 56.8 mm; p < 0.01) so that lean meat percentage was significantly lower for castrated males (59.1 vs. 61.3 %; p <0.01). In conclusion, backfat and muscle depth measures, and lean meat percentage additionally, were unaffected by the diet offered during the fattening period.

2.2 Experiment 2

Feed quantities distributed in Exp.1 and Exp.2 were similar during the growing period, but during the finishing phase the feeding plan was less restrictive for Exp.2. During the growing period of Exp.2, feed distribution was identical for all pens, and ADG did not differ significantly among treatments or sexes (p > 0.1). During the finishing period, control and CP pigs received the same quantities of feed, whereas female pigs were given 9 % more feed than males (2.88 vs. 2.64 kg/d). Thus, ADG was about 22% higher for females than for males (849 vs. 693; p < 0.001). Furthermore, ADG for the finishing period tended to be decreased by the CP2 feed (-7%; p = 0.06), although DFI were very similar. As a result, females had a better FCR than males (3.4 vs. 3.8 kg/kg), and pigs offered the control diet had a better ratio than pigs fed with the CP2 diets (3.5 vs. 3.75 kg/kg, respectively).

For the whole experimental period, feed quantities differed among sex (2.5 and 2.35 kg/d for females and males, respectively) and were similar among treatments. But, the CP2 diet with triticale and 28 % of coloured peas resulted in a lower growth: ADG was lower for CP pigs than for control pigs (-6.6%; p = 0.04). In addition, females had a higher daily gain than males (778 vs. 701 g/d; p < 0.001). Consequently, the calculated FCR for the total period was lower for females than for males (3.2 vs. 3.35 kg/kg) and was increased by the CP treatment (+7%).

Due to this difference of growth, the number of days to reach the slaughter weight was higher for pigs fed with the CP2 diet than for pigs receiving the control feed (p =

Table 4 – Effect of diet composition from 35 kg to slaughtering on carcass characteristics in Exp.1, 2 and 3 [(a)]

	Exp.1				Exp.2				Exp.3			
	control	CP1	rmse	sign. [(b)]	control	CP2	rmse	sign. [(b)]	control	CP3	rmse	sign. [(b)]
carcass weight, kg	88.3	88.0	3.8	ns	86.3	82.3	7.0	T**, S*	87.0	86.4	9.5	ns
dressing percentage	76.0	75.9	1.1	ns	75.5	73.9	0.0	T*** S**	74.1	74.0	1.5	ns
lean meat percentage	*60.3*	*60.1*	*1.6*	S**	58.3	58.2	2.3	ns	59.5	59.0	3.2	S***
g1 Fat depth, mm	16.3	16.0	2.5	S** TxS*	17.4	16.9	3.1	ns	15.4	15.7	4.1	S*
g2 Fat depth, mm	12.9	13.5	1.8	S**	15.7	15.5	3.0	ns	14.2	15.2	3.9	S***
m2 muscle depth, mm	55.8	55.6	4.4	S**	53.1	50.5	4.6	T** S*	52.3	51.9	6.4	ns

(a) values in the table are presented as least-square means and root mean square error (rmse) for 48 pigs per treatment in Exp.1, 50 pigs per treatment in Exp.2 and 40pigs per treatment in Exp.3.
(b) From analysis of variance including the effects of dietary treatment (T), sex (S), and interaction (TxS) with live weight at slaughter as a covariate (except for carcass weight). Statistical significance: *** P < .001, ** P < .01, * P < .05, ns (not significant) P > .05.

0.03). In spite of this, carcass weights were lower for pigs fed the CP2 diet during fattening than for control pigs (-5%; p < 0.01). Male carcasses were also lighter than female carcasses (82.4 vs. 86.2 kg; p = 0.01). Therefore the dressing percentage was less important for the smaller carcasses of CP2 fed pigs (-2%; p < 0.001) and male pigs (74.1 vs. 75.3 %; p = 0.003). Fat depths were not significantly affected by dietary treatment or sex. On the other hand, the CP2 diet decreased significantly the muscle thickness (-5%; p = 0.08). The sex effect on muscle depth was also of 5% (50.5 vs. 53.1 mm for males and females, respectively; p = 0.01). However, because of the heterogeneity in fat depths, this did not resulted in differences of the lean meat percentages among sexes or treatments.

2.3 Experiment 3
Feed distribution of the Exp.3 was the most restrictive. Although pigs from both groups were given the same quantities of feed, pigs of CP group had a significant lower growth during the pre-experimental phase (-6%; p = 0.03) resulting in a lower body weight at the beginning of experimental period (-0.6 kg; p = 0.03).

During the growing phase, a slight but significant interaction (p = 0.04) between the diet and sex effects on daily gain occurred. In this period, ADG of males offered the CP3 diet tended to be better than the gain of control males (636 vs. 564 g/d; p = 0.14), whereas for females, pigs proposed the CP3 diet had the lowest ADG (559 vs. 613 g/d; p = 0.06). As a consequence, at the end of the growing period, live weight was still lower for the females fed the CP3 diet than for control females (57.8 vs. 61.0 kg; p = 0.06), whereas male weight was unaffected by treatment (p = 0.20).
However, during the finishing period and for the total experimental period, daily gains were not influenced by dietary treatment or by sex. At the end of the experiment, live body weight and number of days of fattening did not differ among groups.

At slaughtering, carcass weight and dressing percentage were unaffected by diet and sex. Differences in mean values for carcass characteristics were not influenced by the composition of diet. Sex had effect on backfat depths resulting in a higher lean meat percentage for females than for males (60.5 vs. 57.9 %; p < 0.01).

3. Discussion

Experiments 1, 2 and 3 compared the feeding of simplified fattening diets based on cereals and pulses with a conventional organic diet. According to the standards for organic farming, our organic feeds were prepared without any use of extracted soybean meal or pure amino acids as feed ingredients. Consequently, although all diets had adequate crude protein content, the usual AA requirements for growing and finishing pigs were not met. Moreover, the CP organic feeds produced with a low number of feedstuffs did not achieve the ideal protein pattern.

The lysine contents of the control diets (0.70, 0.73 and 0.73 g dLys /MJ NE in Exp.1, 2 and 3) and the CP diets in Exp.2 and 3 (0.70 and 0.77 g dLys /MJ NE) were 20 % lower than the usual levels recommended for growing pigs from 25 kg. Even if the diets were only given from 35 kg of body weight, amino acids contents were not high enough to prevent in Exp.1 and 3 a decrease of the daily gain during the growing phase in comparison with the pre-experimental period. Furthermore, the CP1 diet in Exp.1 had a lysine content that was not higher than 0.62 g dlys /MJ NE (i.e. 30 % less than the requirement) and was additionally low for tryptophane. As a result, the overall FCR increased for CP1 diet in Exp.1 because of the additional quantities given to CP1 pigs. In Exp.2, the lysine to energy ratios were similar for both diets but the CP2 diet had a poorer balance for sulfur amino acids. Total daily gain during the experimental period, carcass weight and muscle depth were consequently degraded for CP2 pigs. In Exp.3, although the CP diet had a higher lysine to energy ratio than the control diet, it had a lower content in sulfur amino acids, particularly methionine. However, possibly due to a more restrictive feeding than in Exp. 1 and 2, and also because of a higher standard deviation resulting of the sex-mixed housing, no differences in performances were seen.

The effects on carcass characteristics were investigated in the present investigation. Pigs slaughtered in the experiments had a smaller m2 muscle thickness as well as a lower fat depth than conventionally produced pigs in France (Uniporc-Ouest, 2007). This resulted in rather comparable lean meat percentages for Exp.1, 2 and 3 (60.2, 58.2, 59.2%, respectively) and for the national data slaughtering reference (60.0 %). Although measured muscle depths were in all trials numerically lower for pigs fed with the CP diets, no statistical difference was found for Exp.1 and 3.

Brossard et al. (2007) have studied by simulation modelling, the consequences of very low lysine supplies (70 and 80% of the lysine mean requirement, which was evaluated at 0.85 g dLys /MJ NE) on conventionally housed pigs. With 70 % and 80 %, respectively, of the mean requirement in a one-phase feed sequence plan, ADG was decreased by 16 % and 8 %, respectively, of the maximal performance, and FCR increased similarly. With such lysine supplies, the entire population is penalized and consequently the variability in performance is also low. In our study, the heterogeneity of final weights was only increased in Exp.2 (Data not shown).

As a matter of fact, AA requirements are thought to be lower for organic pigs than those of conventional pigs. Organic pigs need an extra energy supply to maintain their body temperature. Data available reviewed by Van Krimpen and Van der Peet-Schwering (2004) shows that organic pigs, most of the time, have a higher DFI and a higher FCR. In our study, no outdoor areas were employed. However, pigs use limitedly the outdoor area when the outdoor temperature is low (Van Krimpen and Van der Peet-Schwering, 2004). Consequently the energy requirement would not have been higher if a free access to outdoor would have been applied in our experiments. In contrast, in the experiment of Millet et al. (2005), pigs housed in the organic barn had a higher feed intake, which over-compensated the energy needs for thermo-regulation and resulted in a higher ADG than for conventionally housed pigs.

Our results are in conformity with those of Millet et al. (2002) who showed that in the growing (from 42 to 71 kg) and finishing (from 71 kg to harvest) phases, the lysine / energy ratios could be of 0.71 and 0.65 g dLys /MJ NE without degrading growth and carcass performances of organic housed pigs in comparison with pigs given the usual standards (0.78 and 0.72 g/MJ, respectively). In contrast, in the first part of the fattening period (up to 42 kg), pigs receiving a less concentrated diet than the standard (i.e. 0.76 vs. 0.84 g/MJ, respectively) had poorer performances. In the same study, a third group receiving diets with very low content in lysine (i.e. 0.68, 0.63, 0.58 g dLys /MJ NE for beginning, growing and finishing phases, respectively) resulted in poorer feed conversion and meat percentage (Millet et al., 2002).
In agreement with these results and others (Fernandez, 2004; Millet et al., 2004; Millet et al., 2005), it appears that the AA to energy content can be reduced of somewhat 10-15 % in growing and finishing diets. With a three-phase feeding applied from 21 kg up to 105 kg, Millet et al. (2005) obtained similar ADG, FCR and carcass characteristics for conventional diets (0.91, 0.84 and 0.72 g dLys /MJ NE for 20-45, 45-70 and 70-105 kg periods, respectively) and iso-energetic but 15 % lower in lysine organic diets (0.79, 0.70 and 0.62 dLys /MJ NE). Although the lysine to energy content can be reduced in organic feeds, the ideal protein pattern has to be satisfied. The present work supports the results of Sundrum et al. (2000) indicating that growing diets which are 15 % lower in lysine, might cause a lower feed intake, a lower daily gain and a lower feed efficiency, if the level for total sulfur amino acids (methionine + cystine) is below 60 percent of the lysine level.

Seeing that pigs were not fed *ad libitum* in our studies, the lysine shortage of the diets could not be compensated by an increased feed intake in order to achieve the daily lysine requirement. In fact, feeding according to an age-related plan is usually applied in organic pig fattening. However, even for pigs fed *ad libitum*, a decrease of the voluntary feed intake might be observed as a consequence of poor balanced in AA diets, particularly for diets which are low in tryptophane (LeFloc'h and Seve, 2007). On the other hand, no forage was given to pigs in the current study. Roughage distribution might result in a limitation of the total energy and protein quantities ingested. A previous study (Hansen et al., 2006) has shown that the *ad libitum* distribution of roughage to pigs given about 70 % of organic concentrate (restricted) results in a lower daily gain than for pigs fed *ad libitum* with the organic concentrate. Furthermore, the feeding restriction related to the roughage distribution products a better lean meat percentage but also a reduced intramuscular fat content (Hansen et al., 2006). Hermansen et al. (2002) underlined the risk of a reduced tenderness of the meat for finishers fed too restrictively.

A one-phase feed was used during the overall fattening period in our experiments. The lysine supply level for a period of age is defined as the maximal mean requirement at the beginning of this period. As the lysine requirement (in g/kg feed) decreases during growth, the number of pigs for which the lysine requirement was met should have been higher during the finishing than during the growing period in our study. In contrast, when decreasing the supply of lysine, a higher percentage of pigs have their requirement not covered by feed. Thus, at the beginning of the growing phase, it can be considered that there should have been a distribution of the phase 2 diet during a more long time.
On the other hand, establishing the lysine value in feed formulation has to be determined by an economical evaluation to avoid disproportionate costs. Even when the supply per kg of feed is low, increasing the number of feeds (by a growing and finishing sequence plan) reduced the total lysine supply and thus the cost in protein sources. The use of two different diets for the growing and finishing phases is often practiced by French organic farmers who buy their feeds (Suire, 2001). Although this practice is not used by small farmers who home-mix their feeds, it is common for others (Albar, 2001, 2002).

The meat content of pigs given *ad libitum* a 15% poorer in lysine organic feed was significantly reduced in a study by Fernandez (2004), whereas in our trials as well as in Millet et al. (2005) experiment, differences of carcass quality were not statistically significant. By contrast, pigs organically housed had a higher feed intake and a faster growth, which led in a lower meat percentage than for pigs conventionally housed (Millet et al., 2005). Thus, meat quality characteristics can be more affected by housing conditions or feeding restriction than by small changes in nutrition. Millet et al. (2005) suggested that the genotypes used in organic production might explain the appearance or the nonappearance of differences in muscle and fat deposits. In point of fact, in a survey of Dutch organic farms by Binnendijk and Van der Peet-Schwering (2006), it was not possible to observe an effect on the carcass quality of higher contents in dLys of the fattening diets.
Moreover, Sundrum et al. (2000) reported a lower lean meat percentage and a smaller longissimus area, with non supplemented in AA diets which contained 9 g of total lysine per kg. On the other hand the intramuscular fat content was significantly increased by the AA exclusion in organic feeds. This consequence is favourable, although pig markets do not take into account this aspect of the meat quality in the payment of the pigs.

The formulation of organic feeds can easily increase the content in home-grown feedstuffs. The energy can be provided by one of the main cereals: triticale, barley, corn, wheat, sorghum or rye. All farm produced cereals can be included in organic pig diets, as a single cereal up to 50 to 60% of the formula or mixed with others. Triticale, which is rich in protein and phytase, is widely grown in organic production (Agence Bio, 2009) and often used for feeding organic pigs (Suire, 2001). Wet corn (silage or anaerobic) is an attractive option thanks to the saving of costs of drying and to the cheap investment in storage. It allowed here a good carcass quality. But, its low protein content requires to limit the incorporation rate at 50% so that other raw materials ensure a proper input into amino acids, especially in the case of the association corn + beans which is poor in tryptophan.
Fibre sources (wheat bran, alfalfa meal, oats, sunflower meal, or forages) are used to limit the energy concentration, which facilitates the ability to balance the AA to energy ratios. The overall contribution of pasture to the energy supply of the growing pig when fed *ad libitum* with concentrates has been reviewed as low (Kongsted and Hermansen, 2005). At last, the use of by-products is also a solution when possible (Wlcek, 2002; Binnendijk and van der Peet-Schwering, 2006).

A main protein input can be provided from pulses. A high inclusion rate is possible in conventional post-weaning and fattening feeds, provided to ensure respect for the requirements in amino acids, particularly methionine (Royer et al., 2004). In organic pig production, previous studies have shown the benefits of lupines, (white) peas and faba beans (Sundrum et al., 2000; Carrouée and Cherrière, 2001; Böttcher et al., 2005).
In the experiment of Sundrum et al. (2000), pigs fed the organic diets without AA supplementation grew more slowly and had a decreased feed intake in the grower period, but nearly the same feed efficiency as pigs fed diets with AA supplementation. These authors discussed the reduction of feed intake as due to the high rates of faba beans (30%) and lupines (20%) in diets. However, other studies have confirmed the impact of anti-nutritional factors in lupins as alkaloids, protease inhibitors or α-galactosides, on the mean intake (Cherrière et al., 2003), which was not observed for faba beans (Royer et al., 2010). In organic farming, faba beans seem to be a more attractive crop than peas due the lower sensitivity for fungal and other diseases (Helsper et al., 2006). The inclusion of 40 or 50 % of peas can allowed the exclusion of soybean meal in organic finishing diets (Böttcher et al., 2005). The coloured peas (*Assas* variety) are grown in organic production, but the tannins and a higher fiber content result in a lower digestibility for energy and protein than for non coloured peas (Grosjean et al., 1998; Carrouée and Cherrière, 2000; Bouvarel et al., 2000). At last, the development of quinoa as a protein rich feed crop is just starting and requires extra research (Helsper et al., 2006).

A supplemental protein source rich in essential AA is necessary to achieve a better balance of limited AA and avoid a reduction of feed intake and growth. The respective cost of the sources as well as the organic regulations will influence the choice. This could correspond to 7-8% of brewer's yeast, or approximately 10% of heat-treated organic soybeans or about 10% of soybean meal produced by mechanical pressure. The potato proteins are reported by previous studies (Sundrum et al., 2000) as a suitable source of limited AA in organic pig production.
The mineral intake could be provided by the inclusion of a premix or feed mineral certified for the organic production (calcium carbonate, dicalcium phosphate, salt, trace elements and vitamins).

Conclusion

The feeding of growing-finishing pigs with organic diets which are not supplemented in amino acids, leads indeed to low growth performances and to a prolonged fattening period. Because of the extra energy requirement to maintain body temperature in organic housing, a reduction of the lysine to energy ratio is possible in organic diets. However, at a level that is 20 % lower than the requirement for conventional growing pigs, growth performances are limited. In diets based on cereals and pulses, a further reduction of the lysine to energy ratio or a poor balance in sulfur amino acids tend to result in additional reductions of daily growth and feed efficiency. However, with a restrictive feeding plan, the effects on the carcass lean meat percentage are limited. Rich in protein organic feedstuffs are rarely produced on the farm and are difficult to find on the market. Thus, the performance degradation of organic diets based on cereals and pulses without processed soybeans products must be compared to the saving on feed costs by using on farm produced raw materials at a maximal incorporation rate. Complementary studies are necessary to clarify the border line between the search of better balanced feeds which enable better performances, and avoidance of too high feed costs for the profitability of organic pig production.

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References

Agence Bio, 2009. Page 105 in L’agriculture biologique: chiffres clés - Ed. 2009. Agence française pour le développement et la promotion de l’agriculture biologique (ed.), Paris, 218 p. [In French.]

Albar J., 2001. Alimentation des porcins en production biologique : quelques repères. Pages 23-34 in Recueil des Journées techniques élevage de l’Institut Technique de l’Agriculture Biologique (ITAB), Limoges 18-19 oct. 2001, ITAB (ed.), Paris, 141 p. [In French.]

Albar J., 2002. L’alimentation en finition en élevage porcin bio. Pages 44-48 in Recueil des Journées techniques élevage de l’ITAB, Besançon, 8-9 oct. 2002, ITAB (ed.), Paris, 124 p. [In French.]

Binnendijk G.P, van der Peet-Schwering C.M.C., 2006. Mogelijkheden ter verbetering van de resultaten van biologische vleesvarkens, [Possibilities of improving performance of organic growing-finishing pigs]. Praktijk Rapport 50 Varkens, ASG (ed.), Wageningen Univ., Lelystad, NL, 31 p. [In Dutch, English.]

Blair R., 2007. Nutrition and feeding of organic pigs. CABI press, Wallingford, UK, 322 p.

Böttcher J., Romberg F.J., Stumm G., 2005. Auswirkungen der Fütterung mit ausschließlich hofeigenen Proteinträgern aus ökologischem Anbau in der Endmast auf die Mast- und Schlachtleistung von Schweinen, [Effects of feeding exclusively farm grown organic protein feed during finishing period on fattening, carcass, and meat performance of pigs]. Available at URL : http://orgprints.org/ 14 pp. [In German, English.]

Bouvarel I., Hatte C., Panheleux M., Cherrière K., Jonis M., 2000. Le pois, principale source de protéines pour les poulets bio. Alter agri, 44, 22-24. [In French.]

Brossard L., Dourmad J.Y., Van Milgen J., 2007. Variation of performance of a growing pig population as affected by lysine supply and feeding strategy, 58th EAAP annual meeting, Session 9, Abstract 0378, 8 p.

Carrouée B., Cherrière K., 2000. Culture de protéagineux en agriculture biologique. Alter agri, 42, 24-26. [In French.]

Carrouée B., Cherrière K., 2001. Pois, lupin, féverole : des graines faciles à utiliser pour nourrir porcs, volailles et ruminants. Pages 14-21 in Recueil des Journées techniques élevage de l’ITAB, Limoges 18-19 oct. 2001, ITAB (ed.), Paris, 141 p. [In French.]

Cherriere K., Albar J., Noblet J., Skiba F., Granier R., Peyronnet C., 2003. Utilisation du lupin bleu (*lupinus angustifolius*) et du lupin blanc (*lupinus albus*) par les porcelets en post-sevrage, [Utilisation of white (*Lupinus albus*) or blue (*Lupinus angustifolius*) sweet lupines in weaned piglet diets]. Journées Rech. Porcine, 35, 97-104. [In French, English.]

Daumas G., 2008. Actualisation de l’équation CGM pour le classement des porcs en France, [Updating the CGM equation for pig grading in France]. Journées Rech. Porcine, 40, 89-90. [In French, English.]

Fernandez, J. 2004. Bedre fodring med egne proteinafgrøder, [Better feeding with home produced protein crops]. Pages 30-31 in Proc. Økologi-kongres, 16-17 November 2004, Odense. [In Danish.]

Grosjean F., Bastianelli D., Bourdillon A., Cerneau P., Jondreville C., Peyronnet C., 1998. Feeding value of pea (*pisum sativum*, L.). 2. Nutritional value in the pig. Animal science, 67:621-625.

Hansen L.L., Claudi-Magnussen C., Jensen S.K., Andersen H.J., 2006. Effect of organic pig production systems on performance and meat quality. Meat Science, 74, 605–615.

Helsper J.P., Balkema-Boomstra A., Ribôt S.A., Groot M.J., van Loo E.N., 2006. Novel protein crops as pig feed in organic farming. Report 112, Plant Research International B.V. (ed.), Wageningen UR, March 2006, 29 p.

Hermansen J.E., Larsen V.A., Andersen B.H., 2002. Development of organic pig production systems. In Perspectives in Pig Science, Proc. 2002 Easter School, 10-13 September 2002, Sutton Bonington Campus, J Wiseman, M. Varley and B. Kemp (eds), Nottingham University Press, Nottingham, UK.

INRA, AFZ, 2004. Tables de composition et de valeurs nutritives des matières premières destinées aux animaux d’élevage : porcs, volailles, bovins, caprins, lapins, chevaux, poissons. Sauvant D., Perez J.M. et Tran G. (eds), INRA Editions, Versailles, 304 p. [In French.]

ITP, ITCF, ADÆSO, UNIP, CETIOM, 2002. Tables d’alimentation pour les porcs. ITP/Ifip (ed), Paris, 40 p. [In French.]

Jakobsen K., Hermansen J.E., 2001. Organic farming - a challenge to nutritionists. J. Anim. Feed Science, 10, Suppl. 1, 29-42.

Kongsted A.G., Hermansen J.E., 2005. Organic pig production – With particular reference to Danish production conditions. 18 p. Available at URL: http://orgprints.org/

Le Floc'h N., Seve B., 2007. Biological roles of tryptophan and its metabolism: Potential implications for pig feeding, Livestock Science, 112 (1-2), 23-32.

Millet S., Seynaeve M., de Smet S., Janssens G.P.J., 2002. De lysinebehoefte van biologische vleesvarkens. Pages 49-50 in 27e Studiedag Nederlandstalige Voedingsonderzoekers, ID-Lelystad, [In Dutch.]

Millet S., Hesta M., Seynaeve M., Ongenae E., De Smet S., Debraekeleer J., Janssens G. P. J., 2004. Performance, meat and carcass traits of fattening pigs with organic versus conventional housing and nutrition. Livestock Production Science, 87, (2-3), 109-119.

Millet S., Raes K., Van den Broeck W., De Smet S., Janssens G.P.J., 2005. Performance and meat quality of organically versus conventionally fed and housed pigs from weaning till slaughtering. Meat Science, 69, 335–341.

Royer E., Chauvel J., Courboulay V., Granier R., Albar J., 2004, Grain legumes, rapeseed meal and oil seeds for weaned piglets and growing/finishing pigs., 55th EAAP annual meeting, Session NCS5 Alternative protein sources, Bled, Slovenia, September 5-9, 2004. 9 p.

Royer E., Crepon K., Granier R., Peyronnet C., Vilariño M., 2010. Incidence du type de féverole et du taux d’incorporation sur les performances du porc en post-sevrage et engraissement, [Effect of faba bean (*Vicia faba* L.) type and incorporation rate on post-weaning and fattening performance of pigs], Journées Rech. Porcine, 42, in press. [In French, English.]

Suire M., 2001. Les pratiques alimentaires dans les élevages porcins bretons. Pages 35-52 in Recueil des Journées techniques élevage ITAB, Limoges 18-19 oct. 2001, ITAB (ed.), Paris, 77 p. [In French.]

Sundrum A., Bütfering L., Henning M., Hoppenbrock K.H., 2000. Effects of on-farm diets for organic pig production on performance and carcass quality. J. Anim. Sci. 78:1199–1205.

Uniporc-Ouest, 2007. Résultats de l’activité 2007. Available at URL : http://www.uniporc-ouest.com/ [In French.]

Van Krimpen M.M., Van der Peet-Schwering C.M.C., 2004. Energie en eiwitbehoefte van biologisch gehouden vleesvarkens [Energy and protein requirement of organic growing-finishing pigs]. Praktijk Rapport Varkens 34, ASG (ed), Wageningen Univ., 20 p. [In Dutch, English.]

Wlcek S., 2002. Die systemkompatible Ernährung von Schweinen im Biologischen Landbau - Untersuchungen zum Aufkommen und Futterwert von Nebenprodukten aus der Verarbeitung biologisch erzeugter Lebensmittel, [The compatible system diet of pigs in organic farming - studies on the production and feeding value of byproducts from the processing of organically produced foods]. PhD Dissertation, Univ. Bodenkultur, Wien, Austria, 102 p. [In German.]