Journal of the Science of Food and Agriculture *J Sci Food Agric* **85**:1543–1549 (2005)
DOI: 10.1002/jsfa.2148

Evaluation of corn cob mix in organic finishing pig nutrition

Sam Millet,[1*] Katleen Raes,[2] Stefaan De Smet[2] and Geert PJ Janssens[1]

[1] *Laboratory of Animal Nutrition, Department of Animal Nutrition, Genetics, Breeding and Ethology, Faculty of Veterinary Medicine, Ghent University, Heidestraat 19, B-9820 Merelbeke, Belgium*
[2] *Department of Animal Production, Faculty of Agricultural and Applied Biological Sciences, Ghent University, Proefhoevestraat 10, B-9090 Melle, Belgium*

Abstract: Two consecutive experiments were performed to evaluate corn cob mix (CCM) inclusion in an organic diet. The experiments were performed in an organic barn on nine pens of four pigs (two barrows and two sows) of commercial breeds from 45 kg to slaughter. In the first experiment, an organic concentrate was mixed with organic CCM-silage to obtain three concentrate:CCM ratios of 1:0, 4:1 and 3:2 (w:w). In the second experiment, three concentrates were produced to obtain diets with equal nutrient levels on a dry matter basis after 0, 200 and 400 g kg^{-1} CCM inclusion respectively. In all groups of both experiments, meat and carcass traits were comparable with common practice and differences between treatment groups were not seen. Feed conversion ratio on an as-fed basis was worse with higher CCM levels in the diet, most likely due to the dilution effect by the lower dry matter content of CCM. In the first experiment, pigs on a higher concentrate:CCM ratio showed a higher feed intake, indicating a compensation for the lower energy density of these diets. In the second experiment, the 400 g kg^{-1} CCM group showed a lower daily dry matter intake ($p = 0.048$) leading to slower growth ($p = 0.015$). This indicated a bulk effect of the CCM in this case. In conclusion, lean carcasses with good meat quality can be obtained even in situations where up to 400 g kg^{-1} organic CCM-silage is included in a balanced organic pig fattening diet. Moreover, a bulk effect of CCM-silage can be used in some cases to limit the typically high dry matter intake in outdoor pig fattening, thereby preventing excessive fat accretion.

Keywords: corn cob mix; finishing pigs; growth; meat quality; performance

INTRODUCTION

Organic animal production is expanding in the European Union since animal welfare and environmental concerns are gaining interest. Organic pig feeds still often contain feedstuffs that, although from organic origin, are imported from far abroad, which disagrees with the idea of sustainable agriculture. Feedstuffs from local origin would better fit within the scope of organic agriculture. Corn cob mix (CCM) might be a practical ingredient from local origin that can be included at fairly low cost. CCM is a semi-moist product, which can easily be stored as silage. The main differences from concentrate feeds are lower dry matter content and unbalanced protein to energy ratio. Therefore, the question arises whether this ingredient can be used in feed formulation without affecting performance and product quality. Feed intake in an organic pig fattening barn has been shown to be considerably higher in comparison to conventionally housed pigs.[1] This may lead to an extra amount of fat deposition,[2] especially when the maximal capacity for protein accretion is exceeded. Therefore, it may be beneficial to lower feed intake to a level below the maximal capacity for protein deposition in finishing pigs.

The semi-moist nature of CCM might cause a bulk effect, and therefore increase satiation. If a bulk effect is attained, the feed intake may go down and the energy intake might be limited. This could alter performance and carcass quality.

The aim of the present study was to determine the effect of organic CCM-silage on voluntary intake of feed, dry matter and energy in an organic pig fattening barn, and the consequences for performance, carcass and meat quality.

MATERIAL AND METHODS

Two experiments were conducted in an organic barn. In the first experiment, a commercial organic feed was mixed with organic CCM-silage at concentrate:CCM ratios of 1:0, 4:1 and 3:2 (w:w). In the second

* Correspondence to: Sam Millet, Laboratory of Animal Nutrition, Department of Animal Nutrition, Genetics, Breeding and Ethology, Faculty of Veterinary Medicine, Ghent University, Heidestraat 19, B-9820, Merelbeke, Belgium
E-mail: Nutrition@UGent.be
Contract/grant sponsor: Ministry of the Flemish Community
(*Received 9 July 2004; revised version received 31 August 2004; accepted 7 September 2004*)
Published online 7 March 2005

experiment, three diets were formulated with similar nutrient contents, but with inclusion of 0, 200 or 400 g kg^{-1} organic CCM-silage. In this way, the effects of CCM inclusion could be separated from other factors. More specifically, the effect of CCM supplementation was evaluated without other changes in feed matrix in the first experiment but this led to changes in amino acid and premix concentration. In the second experiment, these factors were held constant, leading to differences in the feed matrix, other than CCM.

Animals and management

In each experiment, a group of 36 pigs of a commercial breed, (Yorkshire × DL) × Pietrain in experiment 1 and terminal crossbreed of paternal and maternal lines of Seghers Hybrid in experiment 2, was randomly divided over nine pens of four pigs in an organic production unit (two barrows and two sows per pen).

The pigs were kept according to conventional husbandry practices until weaning. One week after weaning they were moved to the organic barn at the experimental production site and grown according to organic production rules.

Each group of four pigs had access to an outdoor area of 8 m^2 with a concrete floor and an indoor area of 8 m^2 bedded with straw. The barn was naturally ventilated and straw was replaced twice a week. Housing was in accordance with the EC regulations on organic production.[3] One self-feeder (four feeder holes) and one nipple waterer were provided in each pen. Environmental temperature was recorded using electronic devices every hour (Testostor, Testo Ltd, Almere, The Netherlands).

All pigs received the same organic starter diet (9.5 MJ NEv, 9 g ileal digestible (ID) lysine kg^{-1}) from weaning until 20 kg body weight (BW), and growing diet (9.6 MJ NEv, 8 g ID lysine kg^{-1}) from 20 to 45 kg BW. At an average BW of 44 ± 5 kg (about 15 weeks of age), the experiment was started. At that moment, all pigs were dewormed (Ivomec®, Merial, Brussels, Belgium) and vaccinated against Aujeszky's disease.

Each pen was randomly assigned to one of three dietary treatment groups (for description of diets, see below).

In the first experiment, pigs were slaughtered when their individual BW reached between 100 and 105 kg, with an average weight of 103 (±4) kg. This took four slaughter days, but each slaughter day included pigs of the three treatment groups. In the second experiment, all animals were slaughtered at the same day, with an average weight of 105 (±7) kg. Feed was withdrawn overnight before slaughtering. The pigs were transported to the nearby experimental slaughterhouse (8 km) in groups of 12 animals at most. The time between arrival at the slaughterhouse and slaughtering varied from 1 to 5 h. Pigs were bled after electrical stunning. Average indoor and outdoor temperature during the first experiment were 20 (±4) °C and 17 (±6) °C, respectively. Average indoor and outdoor temperature during the second experiment were 16 (±4) °C and 12 (±6) °C.

Feed composition

Experiment 1

For each treatment, one feed was used from 45 to 105 kg BW. An organic concentrate was mixed with organic CCM-silage to obtain three concentrate:CCM ratios of 1:0, 4:1 and 3:2 (w:w). On the basis of earlier research,[1] the concentrate was formulated to exclude amino acid deficiencies, even in the 400 g kg^{-1} group (Table 1). The feed was formulated in accordance with EC guidelines on organic production.[3]

The CCM was produced according to organic legislation[4] and ensiled with a plastic seal. For the appropriate use of small amounts of CCM, it was re-ensiled in barrels of approximately 170 kg. The

Table 1. Ingredient composition and computed (analyzed) nutrient content of the concentrate in the first experiment and the corn cob mix (CCM)[a]

	Concentrate	CCM
NEv'97[b] (MJ kg^{-1})	8.7 (8.9)	7.2[c]
Dry matter (g kg^{-1})	882 (901)	(634.3)
Crude ash (g kg^{-1})	68 (59)	12.7 (11.6)
Crude fibre (g kg^{-1})	60 (77.2)	28.4 (28.5)
Crude protein (g kg^{-1})	223 (227)	58.3 (53.2)
Ether extract (g kg^{-1})	43 (56)	27.0 (37.2)
ID LYS[d]	9.1	0.89
ID MET + CYS/ID LYS[d]	0.30	2.0
ID THR/ID LYS[d]	0.66	1.39
ID TRY/ID LYS[d]	0.24	0.24
Ingredients (g kg^{-1})		
Organic wheat	228	
Organic peas	225	
Linseed expellers	185	
Organic barley	75	
Non-gmo soybeans	72.5	
Organic soybean cake	63	
Organic alfalfa	45	
Organic wheat shorts	32.5	
Potato protein	19	
Mineral and vitamin premix	18	
Molasses beet	15	
Chalk	7.6	
Organic corn	7.5	
Monocalcium phosphate	3.3	
VitE/Se	3	
NaCl	1.3	

[a] CCM value as published by DSM Nutritional Products (CCM, 40% core), calculated to a dry matter content of 634 g kg^{-1}.
[b] NEv'97 = net energy for production in pigs according to the Dutch CVB system 1998.
[c] Table value calculated for a 630 g kg^{-1} dry matter basis.
[d] ID MET = ileal digestible methionine, ID MET + CYS = ileal digestible methionine and cysteine, ID THR = ileal digestible threonine, ID TRP = ileal digestible tryptophane and ID LYS = ileal digestible lysine. Supplements (IE gL^{-1}) Vit A: 1000, Vit D3: 200; (mg g^{-1}) Vit E: 4, Vit K3: 0.22, Vit B4: 0.16, Vit B2: 0.38, Vit PP: 2.4, Vit B6: 0.23, folic acid: 0.08, Vit B12 0.0024, Vit H: 0.008, Fe^{++}: 10, Cu^{++}: 0.08, Mn: 7, Co: 0.04, Zn:8, I: 0.04, Se: 0.032, Choline: 35, Ca: 192.5, Na: 89, Mg: 11; endo-1,4-β-xylanase (EC 3.2.1.8) 0.8 IU g^{-1}.

concentrate was produced by Molens Dedobbeleer (Halle, Belgium) and was subjected to proximate analysis.[5]

Experiment 2

For each treatment, one feed was used from 45 to 105 kg BW. Three concentrates were produced to obtain diets with similar nutrient demands on a dry matter basis when respectively 0, 200 or 400 g kg^{-1} CCM was included in the total diet on an 'as fed' basis (Table 2). Therefore, on a dry matter basis, 0, 152 and 323 g kg^{-1} CCM was included [$(200 \times 0.63)/(800 \times 0.88 + 200 \times 0.63) = 152$ and $(400 \times 0.63)/(600 \times 0.88 + 400 \times 0.63) = 323$]. The feed was formulated in accordance with EC guidelines on organic production.[3]

Table 2. Ingredient composition and computed (analyzed) nutrient content of the three experimental diets of the second experiment on an equal dry matter basis

	Inclusion level of CCM[c]		
	0%	20%	40%
NEv'97[a] (MJ kg^{-1})	9.20	9.20	9.20
Dry matter (g kg^{-1})	875 (887)	878 (887)	881 (879)
Crude ash (g kg^{-1})	51 (72)	51 (62)	52 (53)
Crude fibre (g kg^{-1})	54 (115)	58 (76)	59 (60)
Crude protein (g kg^{-1})	175 (204)	175 (175)	176 (181)
Ether extract (g kg^{-1})	42 (54)	42 (50)	44 (46)
ID LYS[b]	6.53	6.53	6.53
ID MET + CYS/ID LYS[b]	0.68	0.66	0.66
ID THR/ID LYS[b]	0.68	0.67	0.67
ID TRY/ID LYS[b]	0.23	0.22	0.22
Ingredients (g/kg)			
Organic triticale	215.7	152.4	178.1
Organic corn	200.0	101.4	00.0
CCM	0.0	152.0	323.0
Organic peas	157.0	200.0	200.0
Organic barley	100.0	100.0	—
Non-GMO soy bean	92.0	89.5	83.4
Linseed expellers	77.9	96.2	107.8
Organic alfalfa	60.0	60.0	51.3
Organic wheat shorts	53.9	23.3	13.7
Organic soybean cake	—	—	21.6
Potato protein	12.6	5.3	—
Mineral and vitamin premix	12.0	12.0	12.0
Beet molasses	10.0	—	—
Chalk	3.4	3.7	4.3
Monocalcic phosphate	3.0	2.5	2.0
VitE/Se	2.0	2.0	2.0
NaCl	0.5	0.7	0.8

[a] NEv'97 = net energy for production in pigs according to the Dutch CVB system 1998.

[b] ID MET = ileal digestible methionine, ID MET + CYS = ileal digestible methionine and cysteine, ID THR = ileal digestible threonine, ID TRP = ileal digestible tryptophane and ID LYS = ileal digestible lysine.

[c] Percentage CCM calculated on an 88% dry matter basis, and thus not as-fed. Supplements (IU g^{-1}) Vit A: 1000 Vit D3: 200 IE g^{-1} Vit E: 4; Vit K3: 0.22; Vit B1: 0.16; Vit B2: 0.38; Vit PP: 2.4; Vit B6: 0.23; Folic acid: 0.08; Vit B12: 0.0024; Vit H: 0.008; Fe++ 10, Cu++ 0.8, Mn: 7; Co: 0.04; Zn: 8; I: 0.04, Se: 0.032%, Choline: 350 mg g^{-1}, Ca: 192.5; Na: 89, Mg: 11; endo-1,4-beta-xylanase E.C. 3.2.1.8. 0.8 IU g^{-1}.

The CCM used in this experiment was the same as the CCM used in the first experiment. Concentrates were produced by Molens Dedobbeleer (Halle, Belgium) and were subjected to proximate analysis.

Measurements

Production traits

Every 3 weeks, pigs were weighed individually. The average daily gain (ADG) was computed per feeding phase as the difference between the final and initial weight of the pen divided by the number of pig-feeding days during that phase. Average daily feed intake (ADFI) was computed as total feed consumed by the pen during a feeding phase, divided by the number of pig-feeding days during that phase. Feed conversion ratio (FCR) was calculated on a pen basis.

In order to make an estimation of the net energy (NE) content of the CCM, feed energy conversion ratio in the first experiment (computed as NE of the feed × FCR) was assumed to be constant, as protein content was not limiting for growth.

Carcass composition and meat quality

At the abattoir, live weight and warm carcass weight were recorded. Muscle thickness and fat thickness were measured using a PG200-device (Giralda Choirometer PG 200, Eurocontroll Breitsameter GmbH, Aichach, Germany) to obtain the carcass lean meat content (Council of the European Union, 1997). Carcass yield was measured as warm carcass weight over live weight at slaughter.

The pH was measured 40 min (pH_1) and 1 day (pH_2) *post mortem* in the loin around the 13th costa (*musculus longissimus thoracis et lumborum*) and in the ham (*musculus semimembranosus*) of both carcass sides. In the same anatomical locations, conductivity (Pork Quality Meter, PQM, Tecpro GmbH, Aichach, Germany) was measured 1 day *post mortem*. The average of the measurements on both carcass sides for each animal was calculated for analysis.

Following the carcass measurements at 1 day *post mortem*, a piece of the loin of the right carcass side anterior to the last rib was removed and sliced. One slice was used for colour measurements. The CIELAB colour co-ordinates (L^*, a^*, b^* values) were determined in quadruplicate with a HunterLab Miniscan device after a 30-min blooming time (D65 light source, 10° standard observer, 45°/0° geometry, 1 inch light surface, white standard; Hunter, Reston, VA USA). In addition, the water-holding capacity of the same slice was measured with the filter paper method described by Kauffman *et al.*[6]

A second slice was used to assess drip losses as the proportionate weight loss after hanging the meat sample in a plastic bag for 48° at 2 °C.[7]

Statistical analysis

Data were analysed using variance analysis (SPSS 12.0 for Windows, SPPS Inc, Illinois, USA). For performance parameters, the fixed effect of CCM content was included, with pen as the experimental unit. When a linear relationship was observed visually, a linear regression analysis was undertaken. For the carcass and meat quality traits, variance analysis was performed. The model included fixed effects of CCM content and gender and their interaction, considering the animal as experimental unit. Carcass weight was included as a covariable and the day of slaughtering was considered as a random effect (in the first experiment).

RESULTS

Experiment 1

The concentrate:CCM ratio did not influence the measured meat and carcass traits significantly (Table 3).

Gender clearly affected fat thickness of the carcass ($p < 0.001$) and lean meat content ($p < 0.001$) as well as drip losses ($p < 0.007$). The sows showed lower fat thickness and a higher meat content than the barrows. Barrows showed lower drip losses. The day of slaughter affected muscle thickness ($p < 0.004$) and tended to affect meat content ($p = 0.081$). PQM in the ham ($p < 0.001$) and CIE L^* value 24 h ($p = 0.009$) *post mortem* were also different throughout the slaughter days. Still, all slaughter day effects were random. Weight at slaughter influenced muscle thickness, with increasing muscle thickness at higher weights ($p < 0.011$).

On a dry matter basis, FCR was numerically lower with decreasing concentrate:CCM ratios ($r = 0.388$, $p = 0.302$ with linear regression analysis).

A positive linear relationship between CCM content and FCR on an as fed basis was detected ($r = 0.757$, $p = 0.018$) with linear regression analysis although ANOVA analysis revealed a P value > 0.05 (Table 4).

Average daily dry matter intake did not differ between the treatment groups.

ADFI tended to rise with a higher CCM level, with again a positive linear relationship in a linear regression analysis ($r = 0.683$, $p = 0.042$).

Average daily gain did not differ significantly between the groups.

Assuming feed energy conversion ratio to be constant, the feed energy conversion ratio of the concentrate feed (8.9×2.8914) was compared with the feed energy conversion ratio of the 200 g kg^{-1} group. The latter was calculated as feed conversion ratio obtained by the regression curve $(0.071 \times 20 + 2.8914) \times$ NE content of the diet with the 4:1 ratio. This led to an estimated NE of the CCM (X) as: $2.8914 \times 8.9 = (0.071 \times 200 + 2.8914) \times (0.8 \times 8.9 + 0.2X)$.

Hence, the estimated net energetic value of the CCM-silage was 6.96 MJ kg^{-1}.

Experiment 2

Corn cob mix content did not influence the measured meat and carcass traits significantly (Table 5). Gender affected fat thickness of the carcass ($p = 0.001$), lean

Table 4. Performance of organic fattening pigs from 45 kg to slaughtering fed different concentrate:CCM ratios (expt 1; $n = 3$ per treatment)

Concentrate:CCM ratio (w:w)	1:0	4:1	3:2	SEM	*P*
Average daily gain (g day^{-1})	843	876	855	15	0.717
Average daily feed intake (kg day^{-1})	2.44	2.63	2.72	0.06	0.135
Average daily feed intake (kg dry matter day^{-1})	2.20	2.23	2.16	0.04	0.793
Feed conversion ratio	2.90	3.01	3.19	0.05	0.072
Feed conversion ratio (dry matter basis)	2.62	2.55	2.53	0.03	0.590

Table 3. Meat and carcass traits of organic fattening pigs fed different concentrate:CCM ratios (expt 1; $n = 12$ per treatment)

Concentrate:CCM ratio (w:w)	1:0	4:1	3:2	SEM	*P*
Carcass yield (g kg^{-1})	828	838	831	5	0.192
Muscle thickness (mm)	62.6	62.4	61.8	1.1	0.812
Fat thickness (mm)	14.7	17.3	15.7	0.7	0.157
Lean meat percentage (g kg^{-1})	602	580	591	8	0.383
pH1 ham	6.14	5.99	6.08	0.04	0.442
pH1 loin	6.05	6.04	6.08	0.02	0.889
pH2 ham	5.63	5.64	5.63	0.02	0.827
pH2 loin	5.53	5.53	5.55	0.01	0.658
PQM ham[a]	10.4	9.7	9.8	0.3	0.643
PQM loin[a]	9.7	9.4	8.8	0.2	0.659
Drip losses (g kg^{-1})	133	133	115	7	0.634
Water uptake, filter paper method, (mg)	128	121	115	3	0.587
CIE L^*[b]	59.4	60.1	56.6	0.9	0.458
CIE a^*[b]	6.5	6.0	6.9	0.2	0.579
CIE b^*[b]	15.9	15.8	15.6	0.2	0.743

[a] Conductivity measured with a Pork Quality Meter (Tecpro GmbH, Aichach, Germany).

[b] L^* (lightness), a^* (redness), and b^* (yellowness): CIELAB colour co-ordinates measured in quadruplicate with a HunterLab Miniscan device after a 30 min blooming time (D65 light source, 10° standard observer, 45°/0° geometry, 1 inch light surface, white standard; Hunter, Reston, USA).

Table 5. Effect of the proportion of corn cob mix (g kg^{-1} CCM) included in a diet on carcass and meat traits of organic fattening pigs (expt. 2; $n = 12$ per treatment)

CCM inclusion (g kg^{-1})	0	200	400	SEM	*P*
Carcass yield (g kg^{-1})	818	813	819	3	0.586
Muscle thickness	66.5	63.1	62.3	1.3	0.481
Fat thickness (mm)	12.7	12.2	12.8	0.5	0.396
Lean meat percentage	61.7	61.4	60.6	0.5	0.543
pH1 ham	6.27	6.26	6.25	0.03	0.978
pH1 loin	6.04	6.09	6.07	0.02	0.432
pH2 ham	5.74	5.69	5.66	0.03	0.701
pH2 loin	5.49	5.48	5.45	0.01	0.780
PQM ham[a]	10.19	10.64	10.57	0.28	0.770
PQM loin[a]	10.06	10.70	10.16	0.31	0.674
Drip losses (g kg^{-1})	57.4	65.5	70.2	4.2	0.527
Water uptake, filter paper method (mg)	0.107	0.106	0.108	0.003	0.903
CIE L^*[b]	57.7	57.3	56.8	0.7	0.910
CIE a^*[b]	7.06	7.4	7.43	0.14	0.478
CIE b^*[b]	15.79	15.81	15.91	0.15	0.665

[a] Conductivity measured with a Pork Quality Meter (Tecpro GmbH, Aichach, Germany).
[b] L^* (lightness), a^* (redness), and b^* (yellowness): CIELAB colour co-ordinates measured in quadruplicate with a HunterLab Miniscan device after a 30 min blooming time (D65 light source, 10° standard observer, 45°/0° geometry, 1 inch light surface, white standard; Hunter, Reston, USA).

meat content ($p = 0.002$) and PQM in the ham ($p = 0.007$). Sows showed lower fat thickness and higher lean meat content them farming. PQM in the ham was lower in sows. Weight at slaughter increased muscle ($p = 0.012$) and fat thickness ($p = 0.004$).

On a dry matter basis, the FCR did not differ between the treatment groups. The level of CCM inclusion elevated FCR on an as fed basis (Table 6) ($r = 0.910, p = 0.001$).

Average daily dry matter intake was affected by the proportion of CCM included, with numerically lower values on the 400 g kg^{-1} CCM feed ($r = 0.671$, $p = 0.048$). In analogy, a significant decrease in ADG with increasing CCM inclusion was noted ($r = 0.770$, $p = 0.015$).

DISCUSSION

The two experiments were conducted to make an evaluation of the use of corn cob mix separate from potential matrix or nutrient effects. Indeed, inclusion of CCM in the first experiment did not lead to a change in other ingredients. However, it led to a lower protein to energy ratio and lower concentrations of the vitamin and mineral premix at higher CCM inclusion rates. These factors were kept constant in the second experiment, with consequently some changes in ingredient composition of the different concentrates. Therefore, while the second experiment had more practical relevance, the first experiment was necessary to exclude the possibility that potential differences are due to other ingredients that were changed by feed formulation.

Table 6. Effect of the proportion of corn cob mix (g/kg CCM) included in an organic pig fattening diet on performance (expt 2; $n = 3$ per treatment)

CCM inclusion (g kg^{-1})	0	200	400	SEM	*P*
Average daily gain (g day^{-1})	974	968	892	15	0.018
Average daily feed intake (kg day^{-1})	2.71	2.91	2.80	0.04	0.117
Average daily feed intake (kg dry matter day^{-1})	2.38	2.42	2.19	0.05	0.023
Feed conversion ratio	2.78	3.01	3.14	0.04	0.004
Feed conversion ratio (dry matter basis)	2.45	2.50	2.45	0.02	0.596

Feed analyses did not reveal major deviations, except for the crude fibre content in the feed during the second experiment. The latter may be due to deviations of some ingredients from their corresponding matrix values.

In both experiments, the CCM inclusion level had no effect on the measured meat and carcass quality traits. Carcass and meat quality were fairly good and comparable with common practice. Therefore, inclusion of CCM up to a level of 400 g kg^{-1} did not endanger meat or carcass quality. The observed effect of gender on meat content is well known.[8,9] Sundrum *et al*[10] demonstrated that the lack of a well-balanced amino acid profile in organic farming may influence carcass quality. However, in the present experiment, even in the 'unbalanced' 400 g kg^{-1} CCM group of the first experiment, the minimal ileal digestible lysine concentrations could be attained, leading to an acceptable carcass conformation.

The derived NE value matched rather well with the table value of 7.2 MJ kg^{-1} (published by DSM nutritional products, Deinze, Belgium).

The assumption of an equal feed energy conversion ratio is not an exact but rather a useful economical approximation, as in field practice the feed conversion ratio together with the lean meat percentage will determine the cost-price per kg of meat.

Experiment 2 confirmed the assumption of an equal feed energy conversion ratio. Indeed, on an equal dry matter basis, the FCR did not differ between the treatment groups. On a dry matter basis, the energy concentration of CCM is somewhat higher than the concentrate (10.2 versus 8.9), leading to energy concentrations on a dry matter basis of 8.9, 9.1 and 9.3 for the 1:0, 4:1 and 3:2 groups, respectively. Therefore, differences in energy concentrations were relatively small (5% between the 1:0 and the 3:2 groups). This might explain the lack of significant differences in FCR on a dry matter basis.

As CCM has a lower dry matter content, the dilution effect was expected to alter feed intake. Whittemore *et al*[11] confirmed the framework that pigs eat to achieve maximum performance, unless they are constrainted, in this case by the bulk content of the feed. Henry[12] concluded from literature data that a decrease in energy density is associated with a compensatory increase in daily feed intake, although to a lesser extent, leading to a slightly lower level of energy consumption. Therefore, in these experiments, although the CCM has no excessive crude fibre content, the dilution effect of the water was expected to limit the dry matter intake and lower the energy intake.

In the two experiments average daily feed intake varied with CCM inclusion. In the first experiment, the pigs tended to compensate the dilution effect of adding CCM by a higher feed intake. Indeed, differences in dry matter intake could not be found.

In the second experiment however, the pigs already showed a high (higher than the first experiment) feed intake when given concentrate. Therefore, the dilution effect of CCM did not lead to a remarkably higher feed intake on an as-fed basis, and even a lower dry matter intake of the 400 g kg^{-1} group was noticed. Therefore, a bulk effect was noticed in the second, but not in the first experiment. Moreover, this bulk effect was not considered favourable in these experiments, as the meat content of the pigs on the concentrates was fairly good. As a result, the use of CCM to limit the feed intake is only beneficial in cases of excessive feed intake typically seen in certain combinations of breeds and housing types, leading to fatter carcasses. A breed effect was demonstrated by Sellier *et al*[13] and Pekas *et al*,[14] who showed an interaction between genotype and diet type on carcass quality.

The changes in daily energy intake when adding a semi-moist product seem to depend on the spontaneous feed intake of concentrate and therefore a bulk effect of CCM can be present in some, but not all cases.

The lower dry matter content of the CCM affected the FCR on an as-fed basis. Indeed, the effects of a higher FCR on higher inclusion rates of CCM can be explained by the dilution effect of the moisture, leading to diets with a lower energy content. As the CCM had a lower NE value on an as-fed basis, higher inclusion rates lead to a worse FCR in both experiments.

None the less, the present trials demonstrate that CCM can be used without causing deterioration of meat content and dry matter feed conversion ratio.

The lower cost of CCM in comparison with concentrates would be helpful in lowering the feed cost, which is quite high in organic pig fattening.[10,15] However, because the use of synthetic amino acids in organic farming is currently prohibited and because this CCM has a low and unbalanced protein content, the inclusion of CCM will be limited by nutritional demands. In these experiments, an inclusion rate of CCM up to 400 g kg^{-1} could be formulated within strict amino acid requirements.

On the basis of the lower feed cost and given that meat content and feed conversion ratio were not affected, the use of CCM in these experiments was considered favourable from an economic point of view. This can alleviate the high feed cost of organic feeds. The major hurdle might be the low protein content of the CCM.

CONCLUSION

Corn cob mix is a homegrown feed ingredient that can be used in (organic) pig fattening. Lean carcasses with good meat quality can be obtained even in situations where up to 400 g kg^{-1} organic CCM-silage is included in a balanced organic pig fattening diet.

Changes in feed intake and feed conversion ratio may be attributed to the lower dry matter content of CCM. A bulk effect can occur in some cases. The use of CCM in organic pig nutrition is considered favourable from an economic point of view. However, the major hurdle will be the lack of a well-balanced protein content.

ACKNOWLEDGEMENTS

The Ministry of the Flemish Community financially supported this study. Thanks go to Herman De Rycke, Steven Galle and Julie Raes for their technical assistance. D Baeyens and the slaughterhouse staff are gratefully acknowledged for their skilful technical assistance in slaughtering and in performing the carcass and meat quality measurements. Thanks go to Johan Meeus (Molens Dedobbeleer) and Wim Govaerts (BLIVO) for practical advice. Thanks also go to Christel Moons for language revision.

REFERENCES

1 Millet S, Hesta M, Seynaeve M, Ongenae E, De Smet S, Debraekeleer J and Janssens GPJ, Performance, meat and carcass traits of fattening pigs with organic versus conventional housing and nutrition. *Livest Prod Sci* **87**:109–119 (2004).
2 Olsson V, Andersson K, Hansson I and Lundstrom K, Differences in meat quality between organically and conventionally produced pigs. *Meat Sci* **64**:287–297 (2003).
3 Council of the European Union, Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production. *Official Journal* **L222**:1–27 (1999).
4 Council of the European Union, Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs. *Official Journal* **L198**:1–15 (1991).

5 AOAC, *Official methods of Analysis of the Association of Official Analytical Chemists*, 13th edn. AOAC, Arlington, VA (1980).

6 Kauffman RG, Eikelenboom G, van der Wal PG, Merkus G and Zaar M, The use of filter paper to estimate drip loss of porcine musculature. *Meat Sci* **18**:191–200 (1986).

7 Honikel KO, How to measure the water-holding capacity of meat? Recommendation of standardized methods, in *Evaluation and control of meat quality in pigs*, ed by Tarrant PV, Eikelenboom G and Monin G. Martinus Nijhof, Dordrecht, The Netherlands, pp 129–142 (1987).

8 Thomke S, Madsen A, Mortensen HP, Sundstol F, Vangen O, Alaviuhkola T and Andersson K, Dietary energy and protein for growing pigs 1. Performance and carcass composition. *Acta Agric Scand A–Anim Sci* **45**:45–53 (1995).

9 Youssao IAK, Verleyen V, Michaux C and Leroy PL. A comparison of the Fat Lean Meter (CGM), the ultrasonic device Pie Medical 200 and the Piglog 105 for estimation of the lean meat proportion in Pietrain carcasses. *Livest Prod Sci* **78**:107–114 (2002).

10 Sundrum A, Butfering L, Henning M and Hoppenbrock KH, Effects of on-farm diets for organic pig production on performance and carcass quality. *J Anim Sci* **78**:1199–1205 (2000).

11 Whittemore EC, Kyriazakis I, Emmans GC and Tolkamp BT, Tests of two theories of food intake using growing pigs—1. The effect of ambient temperature on the intake of foods of differing bulk content. *Anim Sci* **72**:351–360 (2001).

12 Henry Y, Dietary factors involved in feed-intake regulation in growing-pigs—A review. *Livest Prod Sci* **12**:339–354 (1985).

13 Sellier P, Houix Y, Desmouli B and Henry Y. Preliminary observations on relationship between nutrition status and genotype in gilts. *Annales de Zootechnie* **23**:405–406 (1974).

14 Pekas JC, Yen JT and Pond WG, Gastrointestinal, carcass and performance traits of obese versus lean genotype swine—effect of dietary fiber. *Nutr Rep Int* **27**:259–270 (1983).

15 Millet S, Janssens GPJ, Hesta M and De Wilde R. Biologische vleesvarkensteelt: mogelijkheden en moeilijkheden. Vlaams *Diergeneeskundig Tijdschrift* **70**:271–278 (2001).