EFFECTS OF THE INCLUSION OF INDUSTRIAL BY-PRODUCTS IN PIG DIETS ON CARCASS AND MEAT QUALITY TRAITS

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Abstract – The effects of including rapeseed meal (RSM) and cereal by-products in pig diets on growth and carcass and meat quality were studied. Two experiments were conducted. In experiment 1, two diets were applied, one conventional (RC) and other including RSM (RR; 120 g/kg during growing phase and 200 g/kg during finishing phase). In experiment 2, animals were fed a conventional diet (BC) or a diet containing rice bran and hominy feed (BB; 60 and 120 g/kg, respectively, during growing phase and 80 and 125 g/kg during finishing phase). Weight and feed intake were controlled. Carcass and meat quality traits were studied. The fatty acid composition of the subcutaneous fat was analyzed. Growth performance and most carcass traits were similar between diets in both experiments. However, fatty acid composition was modified. In experiment 1, RR group showed lower saturated fatty acid (SFA) and greater monounsaturated fatty acid (MUFA) percentages; in experiment 2 animals fed with BB diet showed lower SFA and MUFA but greater polyunsaturated fatty acid (PUFA) percentages. Levels up to 200 g/kg of RSM in pig diets did not impair overall performance and meat quality. However, diets combining rice bran and hominy in pigs might compromise fat firmness.

I. INTRODUCTION

The use of non-conventional feedstuffs derived from the biofuel and food industry in animal feeding is becoming increasingly important. It helps to decrease feed costs and competition between animal feed and human food. Rapeseed meal (RSM) from the biodiesel industry can potentially be used as a protein source in pig diets. Other by-products such as rice bran and hominy feed coming from rice and beer industries, respectively, can be used as energy sources. The suitability of alternative feedstuffs to be used in animal feeding depends not only on its nutritional value, but also on its effects on carcass and meat quality. Due to its variable content in fiber and antinutritional factors, high RSM levels in diets can sometimes be associated to a decreased growth performance [1,2]. Additionally, high levels of fibrous by-products, including RSM, in finishing pigs might negatively influence carcass yield and quality [3]. Studies reporting the consequences of including hominy feed and rice bran in diets on performance and meat quality are scarce. However, due to their high fiber and unsaturated fat content, effects in carcass quality and fat consistency might be expected [4]. The present study investigates the effects of including high levels of these by-products in pig diets on growth performance and carcass and meat quality.

II. MATERIALS AND METHODS

Two experiments were performed. In experiment 1 (exp. 1), 96 pigs of 42.4 ± 4.04 kg of weight were allocated into two dietary treatments: a conventional diet (RC) and a diet containing RSM (RR). Rapeseed meal was added in substitution of soybean meal. The level of RSM in the RR diet was 120 g/kg during the growing phase (40-70 kg) and 200 g/kg during the finishing phase (70-114 kg). In experiment 2 (exp. 2), 160 pigs of 30.0 ± 3.77 kg were also allocated into two dietary treatments: a conventional diet (BC) or a diet containing by-products from cereals (rice bran and hominy feed, BB). These by-products replaced sorghum and barley in diets. The level of rice bran and hominy feed in the BB diet was 60 and 120 g/kg, respectively, during the growing phase (30 to 70 kg BW) and 80 and 125 g/kg during the finishing phase (70 to 110 kg BW). Live weight and feed consumption were controlled in both experiments and the average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) were then calculated. The total duration of the experiments was 76 (exp. 1) and 90 days (exp. 2).

At the end of the experimental period (113.5 ± 12.17 kg BW in exp. 1 and 104.6 ± 9.5 kg BW in exp. 2) pigs were slaughtered. Fasting was practiced for approximately 12 hours before slaughter. Hot carcass weight and carcass composition were recorded immediately after slaughter from all animals. Carcass yield was calculated (hot carcass/ live weight). Carcass composition (lean meat percentage in the carcass and in the main cuts, lean and fat thickness at the 3rd - 4th rib and fat percentage in ham) was measured using an ultrasonic automatic carcass grading device (AutoFomTM, Carometec food technology, Denmark). At 2 h post-mortem three measures were registered at the left side of the carcass: pH in the *Semimembranosus* muscle, fat thickness at the level of the *Gluteus medius* muscle and meat color parameters (lightness, L*; redness, a*; yellowness, b*) at the *Gracillis* muscle (CR300 Minolta Chromameter, Konica Minolta, Osaka, Japan). A sample of subcutaneous fat was removed at the second cervical vertebrae from 12 (exp. 1) and 15 (exp. 2) animals per treatment. Fat samples were transported to the laboratory within 24 h in cold (4ºC) conditions and stored at -80ºC in vacuum-packed opaque bags until fatty acids (FA) analyses were performed. Before storage, color (L*, a*, b*) was also determined in subcutaneous fat at 24 h post-mortem. For determining the FA profile in the subcutaneous fat, fatty acid methyl esters (FAME) were prepared [5] and analyzed in a Focus Gas Chromatograph (Thermo, Milan, Italy). The individual FA were identified by comparing their retention times with standards of FAME supplied by Supelco (PA, USA) and quantified using C21:0 as internal standard. Saturated fatty acids, MUFA and PUFA were expressed as a percentage of total fatty acids and the PUFA/SFA ratio was calculated. The iodine value of subcutaneous fat was calculated using the equation described by the American Oil Chemist's Society [6].

Data were analyzed using SAS System Software (SAS Inst. Inc., Cary, NC). Differences in growth performance and carcass and meat quality traits were tested by analysis of variance using the GLM procedure of SAS. In all cases, the dietary treatment was considered the main class factor and sex was additionally included as a block factor in the model.

III. RESULTS AND DISCUSSION

In exp. 1, pigs from the RR group showed a lower ADG than RC animals during the growing phase (P = 0.011; data not shown). However no differences were found on total ADG, ADFI and FCR (Table 1). Literature shows contradictory results on growth performance when including high levels of RSM in pig diets. While some studies did not find differences in performance feeding diets with up to 210 g/kg of RSM [7,8], others showed negative effects on growth performance with lower RSM inclusion levels (75 – 200 g/kg) [1,2]. The variability among RSM sources (composition and antinutritional factors) could explain these controversial results. The inclusion of the particular source of RSM used in the present study (per kg dry matter: 371 g crude protein, 349 g neutral detergent fiber and 1469 mg isothiocyanate) did not compromise growth performance at high (up to 200 g/kg) inclusion levels.

Animals fed RR diet showed higher b* in the *Gracillis* muscle and lower L* in the subcutaneous fat, compared with animals fed with RC diet (Table 1). Other carcass and meat quality traits showed no difference among treatments. As regards to subcutaneous fat composition, pigs fed with RR diet had a lower SFA and a higher MUFA percentage than RC animals. The PUFA percentage was similar between treatments and the ratio PUFA/SFA was greater in RR animals. In terms of individual FA, RR animals showed a lower C18:0 and higher C16:1-n7, C18:1n-7, C20:1n-9, C18:2n-6 and C18:3n-3 content (mg/100 g fat) than RC animals (data not shown). The calculated iodine value of the subcutaneous fat was higher in RR animals compared to RC animals. In agreement with the variable results obtained for growth performance, the inclusion of RSM in diets shows variable effects on carcass and meat quality in the literature. Although high (500 g/kg) levels of fibrous by-products like RSM in pig diets can decrease carcass yield [3], other studies, including the present work, showed no effects at inclusion levels of 180 to 240 g/kg of RSM [8,11]. The differences found in meat and fat color in the present study were not expected and not reported in previous studies.

Fatty acid profile of the subcutaneous fat and iodine value changed with the inclusion of RSM (table 1). Adequately firm pork fat should have the iodine value below 74 [12]. In exp. 1, the calculated value was lower than this level and no visual or technological problems related with fat firmness were detected. On the other hand, differences obtained in FA profile in exp. 1 might not be directly attributable to RSM, but to the combined effect of fat addition when soybean meal is partially replaced by RSM in diets. The greater fiber content and the lower fat content of RSM compared to soybean meal implied the need for increasing added fat levels to maintain energy.

Table 1 Growth performance, carcass and meat quality traits of pigs fed a control (RC) diet or a diet including rapeseed meal (RR)

	Treatments			
Item	Control	Rapeseed meal	SEM	P-value
Daily gain, g/d	972.9	914.9	21.46	0.071
Daily feed intake, g/d	2307.2	2217.9	64.88	0.342
Feed conversion, g/g	2.38	2.44	0.032	0.260
Carcass yield, %	74.7	74.2	0.7	0.585
Carcass lean, %	58.3	58.6	0.3	0.578
Ham lean, %[b]	44.7	45.0	0.4	0.598
Loin lean, %[b]	60.0	60.5	0.5	0.452
Lean at 3rd-4th rib, %	56.8	56.1	0.9	0.585
Fat thickness at 3rd-4th rib, mm	15.9	15.3	0.5	0.365
Ham fat, %	11.5	11.1	0.3	0.365
Fat thickness at *Gluteus medius*, mm	11.5	10.9	0.6	0.426
pH at *Semimembranosus*	6.23	6.27	0.04	0.477
Color				
Gracillis				
L*	35.5	35.6	0.5	0.813
a*	10.6	10.8	0.3	0.662
b*	0.9	1.8	0.2	<0.001
Subcutaneous fat				
L*	75.1	74.7	0.1	0.036
a*	2.3	2.6	0.1	0.150
b*	3.8	3.6	0.1	0.487
Fatty acid profile				
SFA	37.43	34.40	0.57	<0.001
MUFA	45.80	48.01	0.50	0.003
PUFA	16.77	17.60	0.34	0.088
Ratio PUFA/SFA	0.45	0.51	0.02	0.005
Iodine value	67.20	70.60	0.67	<0.001

L* = lightness; a* = redness; b* = yellowness.
SFA = saturated fatty acid percentage
MUFA = monounsaturated fatty acid percentage
PUFA = polyunsaturated fatty acid percentage

In exp. 2, no differences were detected in ADG, ADFI and FCR between treatments (Table 2). Studies describing the maximum inclusion levels for these by-products in pig diets are scarce in the literature. However, previous studies reported a similar energy content of these by-products compared to cereals for pigs [9,10]. According to the present study, it is possible to substitute moderate levels of cereals (sorghum and barley) by a combination of hominy feed and rice bran in diets for pigs from 30 to 110 kg.

Table 2 Growth performance, carcass and meat quality traits of pigs fed a control (BC) diet or a diet including cereal by-products (BB)

	Treatments			
Item	Control	Cereal by-products	SEM	P-value
Daily gain, g/d	839.5	818.5	10.16	0.155
Daily feed intake, g/d	2032.3	1991.1	28.44	0.416
Feed conversion, g/g	2.43	2.45	0.028	0.636
Carcass yield, %	74.2	73.8	0.41	0.501
Carcass lean, %	59.1	58.9	0.26	0.698
Ham lean, %	45.5	45.4	0.28	0.711
Loin lean, %	61.0	61.0	0.35	0.969
Lean at 3rd-4th rib, %	58.4	56.4	0.65	0.030
Fat thickness at 3rd-4th rib, mm	15.0	14.6	0.30	0.341
Ham fat, %	10.9	10.6	0.21	0.340
Fat thickness at *Gluteus medius*, mm	0.91	0.91	0.057	0.978
pH at *Semimembranosus*	5.91	5.83	0.060	0.268
Color				
Gracillis				
L*	41.7	42.1	0.53	0.499
a*	7.7	7.8	0.32	0.699
b*	1.16	1.17	0.128	0.977
Subcutaneous fat				
L*	73.3	74.7	1.53	0.483
a*	2.7	2.6	0.28	0.777
b*	3.7	3.7	0.26	0.881
Fatty acid profile				
SFA	35.9	34.3	0.5	< 0.05
MUFA	46.8	42.53	0.5	< 0.001
PUFA	17.3	22.2	0.5	< 0.001
Ratio PUFA/SFA	0.48	0.65	0.02	< 0.001
Iodine value	68.97	74.43	0.70	< 0.001

L* = lightness; a* = redness; b* = yellowness.
SFA = saturated fatty acid percentage
MUFA = monounsaturated fatty acid percentage
PUFA = polyunsaturated fatty acid percentage

Animals fed with hominy feed and rice bran showed a lower percentage of lean at 3rd – 4th rib (Table 2).

Other carcass and meat quality traits showed no difference among treatments. Regarding FA profile of subcutaneous fat, animals fed with BB diets presented a lower SFA and MUFA percentage compared to BC animals. However, PUFA percentage was higher in animals fed BB diet, mostly due to an increase on C18:2n-6, C18:3-n-6 and C20:2n-6 content (mg/100 g fat). Fat from animals fed BB diet showed a higher ratio PUFA/SFA and iodine value. Hominy feed and, especially, rice bran are by-products with a high fiber and fat content, compared to cereals. As previously discussed in exp. 1, the inclusion levels of by-products tested in the present study did not lead to differences in carcass yield, as expected when high fibrous ingredients are added to diets. However, significant changes on FA profile were found. The high PUFA levels found in the pigs fed diets with cereal by-products might compromise fat firmness. In fact, the estimated iodine value of these pigs in exp. 2 reached the limit for adequately firm pork [12]. Contrary to exp. 1, this effect is considered a direct consequence of the replacement of cereals by hominy feed and rice bran. Farrell and Hutton (1990) also reported differences in fat firmness when rice by-products were fed to pigs. Then, suggestions that these energy by-products in diets might lead to inferior fat quality were substantiated by exp. 2.

IV. CONCLUSION

The inclusion of RSM in pig diets was safe in terms of overall growth performance and meat quality traits. However, diets combining rice bran (80 g/kg) and hominy feed (125 g/kg) in finishing pigs could lead to changes in FA profile that compromise fat firmness.

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