Effects of glucosinolates and fibre resulting from rapeseed meal inclusion in phase 2 diet on piglet feeding behaviour and performance

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Abstract: At high inclusion rate, rapeseed meal (RSM) may appear as a low palatability ingredient affecting pig feed intake. Two experiments were conducted to evaluate factors, mainly glucosinolates (GSL) and fibre content, which could influence feed intake during the post-weaning period from 12 to 30 kg (phase 2). In Exp.1, different batches of RSM were included in a control diet phase 2 containing 9% RSM and in three experimental diets with 15% RSM to compare increasing contents of GSL, respectively 1.2, 1.6, 2.0 and 2.2 µmol/g feed. Intake and growth did not differ between diets confirming the safe limit of 2.0 µmol GSL per g. In Exp.2, a control phase 2 diet with a high fibre proportion (49 g/kg ADF) coming from wheat bran and corn gluten feed and with 5% RSM was compared to a diet with 15% of RSM (72 g/kg ADF). A standard feeding space allowance and a higher degree of competition (62 vs. 35 mm trough length per pig, respectively) were also compared using a factorial design. Competition decreased feed intake and growth, but there was no diet x competition interaction. An interaction between live weight class and diet occurred, which resulted from RSM fed pigs having a lower feed intake (1009 vs. 1076; P<0.01) and gain (593 vs. 649; P<0.01) than control pigs for the lightest weight group, whereas no difference was observed for medium and heavy groups. This could be explained by the upper daily intake of a highly digestible phase 1 diet by light weight piglets before switching to the phase 2 diets. It is concluded that GSL content and fibre level are important criterion when formulating pig diets.
Key words: rapeseed meal, glucosinolate, fibre, piglet, competition.

INTRODUCTION

The high prices of feed raw materials enforce the necessity of investigating the maximum incorporation levels of cost-effective ingredient such as rapeseed meal (RSM). Among the components of RSM that may reduce palatability or nutrient availability in pig diets, glucosinolates (GSL) and degradation products but also the fibre content play a key role (Bellostas et al., 2007). For several years, a low average GSL content (±10 µmol/g), but without decreasing protein solubility because of excessive heating, has been shown for RSM produced by crushing plants in France (Dauguet et al., 2011). In addition, a previous study recorded no adverse effect on piglet performance when including 12% RSM with GSL content up to 15.4 µmol/g DM in phase 2 diets (Royer and Gaudré, 2008). But, in the same study, a 15% inclusion appeared to lead to a slight decrease in feed intake, more pronounced in good rearing conditions, and possibly due to the high fibre content of the diet. Furthermore, Mathé et al. (2003) reported that the presence of an ingredient such as peas in feed influenced some eating behaviour criteria of pigs, whereas the total feed intake was not modified. Even so, the intake could have been altered under higher competition condition. Accordingly, our hypothesis was that RSM would modify feeding behaviour which would result in unequal intake of RSM diets, particularly if pigs had less time to access the feeders. The objectives of this study were, therefore, to investigate the effects of GSL and fibre resulting from RSM, and of the competition degree at feeding, on feed intake and performance of phase 2 piglets.

MATERIALS AND METHODS

Two experiments were conducted to examine the effects of the dietary GSL level (Exp.1), and the incidence of adding RSM to a diet with a high fibre proportion in different competition degrees (Exp.2). In both experiments, control diets with a RSM proportion of 9% (Exp.1) or 5% (Exp.2) were compared to diets with 15% RSM. Commercial batches of RSM were used. Piglets from Ifip Research Centre (Villefranche de Rouergue, France) were weaned at about 28 d of age and 8.2 ± 1.5 kg of BW in Exp. 1 and 8.5 ± 1.7 kg of BW in Exp. 2, and formed into single-sex groups of even weight. These groups were blocked on the basis of sex (barrows and gilts) and weight and randomly affected to 24 fully slatted pens. Piglets received *ad libitum* in feeders a common phase 1 diet up to 12 kg of weight, for a duration depending of their initial body weight class, then the experimental phase 2 diets. These were prepared in meal form in the Ifip manufactory and were formulated to meet the usual nutritional requirements. Within each experiment, all diets were balanced for net energy concentration (9.60 and 9.40 MJ/kg in Exp.1 and 2, respectively) and amino acids (1.20 g digestible lysine per MJ of NE). The mineral supplement supplied 0.6 mg iodine per kg.

In Exp.1, 300 piglets (P76xLWxLd) were distributed among four dietary treatments with 6 sex-mixed pens of 12 or 13 piglets each, per treatment. The 9% RSM control diet was compared to three diets with a 15% inclusion of three different RSM containing 12, 15 or 16 µmol GSL per g dry matter (DM). In Exp.2, 360 piglets (PPxLW/LWxLd) were affected to 1 of 4 treatments in a 2 x 2 factorial design. The experiment consisted of six blocks with sex and live weight classes (light, medium, and heavy) as the basis for blocking. The phase 2 control diet with a high fibre proportion coming from wheat bran and corn gluten feed, and with 5% RSM, was compared to a diet with 15% of RSM. A low and a high degree of competition were also compared (13 vs. 17 single-sex piglets per pen, 62 vs. 35 mm trough length and 0.34 vs. 0.26 m^2 per pig, respectively).
Representative samples of the RSM were collected to perform HPLC analyses of total GSL (NF ISO 10633-1, Cetiom laboratory, Ardon, France). The breakdown products of GSL have not been measured. Feeds have been chemically analyzed. Piglets were individually weighed at entry, when introducing phase 2 diets and at the end. Data analysis was performed using the GLM procedure (SAS Inst., Cary, NC). Pen was considered the experimental unit. In Exp.1, the analysis was performed with the main effect of diet and the initial weight of the pen as a covariate. In Exp.2, the model included main effects of competition (C), diet (D), sex (S), weight class (W), and their interactions. Weight at begin of dietary phase 2 was introduced as a covariate for phase 2 daily gain and final weight criteria. The Tukey test was used for mean comparisons between treatments.

RESULTS

RSM and diets characteristics. The RSM batches used in Exp.1 (R1, R2, R3) and Exp.2 (R4) had similar CP content compared to the French Tables (Sauvant et al, 2004) but the lysine content was slightly higher. The amounts of CF, NDF and ADF in R1 and R2 were less important than those of the RSM in Tables, while R2 and R3 had similar levels (data not shown). Protein solubility in 0.2% NaOH solution was respectively 52, 56, 47 and 57 % for R1 to R4 meals. In Exp.1, the GSL content of control, R1, R2 and R3 RSM diets was 1.2, 1.6, 2.0 and 2.2 µmol/g as fed basis, respectively. Crude fibre value of the diets was 38, 39, 46, and 46 g/kg, and NDF content was 124, 125, 134 and 136 g/kg, respectively. In Exp.2, the R4 meal had 17 µmol GSL per g DM. Thus, the GSL content was 0.75 µmol/g in the control diet, and 2.25 µmol/g in the 15% RSM diet (as fed). The control diet had crude fibre, NDF, and ADF contents of 40 g, 137 g and 49 g per kg, respectively, and the 15% RSM feed had contents of 52 g, 163 g and 72 g per kg, respectively.
Experiment 1. During the phase 2 period, daily feed intake (DFI) was not influenced by the increasing GSL content of dietary regimen (Table 1). Therefore, average daily gain (ADG) did not differ among treatments. Feed conversion ratios were not modified.
Experiment 2. Pigs reared in high competition degree had a lower DFI, during the phase 2 period, than others (-11%, $P < 0.001$; Table 2). An interaction occurred between diet and weight class ($P = 0.03$). Light piglets offered 15% RSM ate less than control piglets (1009 vs. 1076; $P < 0.01$), whereas no difference was detected for medium and heavy piglets (means: 1073 and 1062 g/d, respectively). ADG of high competition piglets was significantly

Table 1 - Effect of GSL content in phase 2 diet on piglet post-weaning performance in Exp.1[1]

GSL content	1.2	1.6	2.0	2.2	RMSE	Stat.[3]
Weight, kg						
Weaning	8.2	8.2	8.2	8.2		NS
Phase 2[2]	12.8	12.8	12.6	12.6	0.3	NS
Day 41	29.3	29.8	29.4	29.8	0.8	NS
Pre-experimental phase 1 period[2]						
DFI, g	416	415	412	412	22	NS
ADG, g	296	295	281	281	16	NS
FCR, kg/kg	1.41	1.41	1.47	1.47	0.07	NS
Experimental phase 2 period[2]						
DFI, g	1057	1078	1066	1110	60	NS
ADG, g	638	660	648	665	29	NS
FCR, kg/kg	1.65	1.63	1.64	1.67	0.05	NS

1 Values in the table are presented as least-square means and root mean square error for six sex-mixed pens of 12 or 13 piglets each.
2 Durations of phase 1 and phase 2 periods were 12 and 29 d, 15 and 26 d, 19 and 22 d, for heavy, medium and light piglets respectively.
3 P value from analysis of variance including the effect of treatment and initial weight as covariate. NS: not significant, P > .05.

Table2 - Effects of the competition degree, and of a 15 % RSM inclusion in phase 2 diet, on piglet post-weaning performance in Exp.2[1]

Competition degree	Low		High		RMSE	Effects[3]		
Diet	Control	RSM15	Control	RSM15		C	D	interactions
Weight, kg								
Weaning	8.5	8.5	8.5	8.5	0.0	NS	NS	NS
Phase 2[2]	12.2	12.2	12.1	12.1	0.2	NS	NS	NS
Day 40	30.9a	30.5a	28.9b	28.4b	0.3	***	**	D.W***
Pre-exp. phase 1 period[2]								
DFI, g	354	361	336	343	17	*	NS	NS
ADG, g	278	272	264	263	19	NS	NS	NS
FCR, kg/kg	1.31	1.35	1.28	1.34	0.13	NS	NS	NS
Exp. phase 2 period[2]								
DFI, g	1129a	1111a	1005b	991b	28	***	NS	D.W*, C.S**
ADG, g	687a	668a	611b	592b	11	***	**	D.W***
FCR, kg/kg	1.63	1.66	1.66	1.68	0.04	NS	NS	NS

1. Values are least-square means and root mean square error of six pens of 13 (low competition) or 17 piglets (high competition) each.
2. Durations of phase 1 and phase 2 periods were 9 and 31 d, 13 and 27 d, 16 and 24 d, for heavy, medium and light piglets respectively.
3. P value from analysis of variance including the effects of competition degree (C), diet (D), weight class (W), sex (S) and interactions (simple effects of weight and sex are not shown). Initial weight of the pen was added as effect for phase 2 ADG and d 40 weight as covariate. Statistical significance: *** P < .001, ** P < .01, * P < .05, not significant (NS) P > .05. Within a row, treatment values not followed by the same superscript differ (P > .05).

degraded (-11%, P <0.001). Additionally, the effects of diet and of the interaction between diet and weight class were significant. Within the light weight class, piglets fed 15% RSM had less ADG than piglets fed 9% RSM (593 vs. 549 g/d, - 9%, P <0.001), whereas there was no difference for medium (-3% NS) and heavy piglets (+ 2% NS). Lastly, feed conversion was not significantly influenced by the studied factors.

DISCUSSION AND CONCLUSIONS

RSM has a smaller content in energy and amino acids than soybean meal, mostly because it has less crude protein and more fibre. Moreover, the proportion in GSL and the protein availability of RSM are influenced by the rapeseed varieties used and by the oil extraction process. In our study, RSM batches were of good nutritional quality, although protein solubility of R3 RSM in Exp.1 was lower. Thus, it was possible, in both trials, to formulate phase 2 diets that included 15% RSM and that were isoenergetic and isolysinic compared to control diets. These formulations resulted in excellent growth performance.

However, in feed preference tests, pigs are sensitive to about 1 µmol/g of GSL (Schöne et al., 1991), or to a 10% inclusion of RSM (Roura et al., 2007). Consequently, diets formulated to equal net energy and amino acids may still result in unequal ADG because of differences in DFI. Nevertheless, in Exp.1, an increased dietary concentration of GSL up to 2.2 µmol/g did not affect the feed intake of phase 2 piglets. This result goes beyond our previous observations with diets containing 1.7 or 1.9 µmol/g of GSL (Royer and Gaudré, 2008). Schöne et al. (1997) found that pigs tolerate a 2.4 µmol/g (as fed) of dietary GSL without impacts on intake, weight gain or thyroidal function. Nevertheless, differences may subsist among studies testing GSL levels, depending on structural types of GSL and on the formation of GSL degradation products. These substances are usually not determined in studies, because of a lack of analytical methods, but they could result in negative biological effects. Consequently, total GSL content in post-weaning and fattening diets should preferentially be kept below the safe limit of 2.0 µmol/g previously proposed by Schöne et al. (2002).
In Exp.2, the 15% RSM diet had also a high GSL content (2.25 µmol/g), whereas its fibre content was similar to the values (47 to 50 g CF per kg) of a 15% RSM feed that caused poor performance in our previous study (Royer and Gaudré, 2008). We expected the differences of GSL and fibre contents of Exp.2 diets to result in an interaction with the competition degree at feeding. This hypothesis was rejected, as there was no difference on competition incidence on feed intake between the diets.
Surprisingly, an interaction on feed intake and growth occurred in Exp.2 between the effects of diet and live weight class. The lower intake of 15% RSM phase 2 diet for the lightest piglets could be explained by their initial upper daily intake of a highly digestible phase 1 diet compared to medium and heavy piglets (respectively 426, 374 and 246 g/d). More research should determine if a progressive transition from phase 1 to phase 2 diet would result in a different outcome.

Piglets tolerate doses up to 2.2 µmol/g of GSL resulting from the use of RSM at 15% in phase 2 diets. This incorporation level is not affected by the degree of feeding competition. The GSL and fibre contents in pig diets are more important criteria to formulate than the RSM percentage. Further investigations should be done to investigate the effects of intake level and fibre content on the adaptation of piglets to a new feed.

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