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With financial support from:

& European Agricultural Fund for Rural Development

RAPESEED CAKE FOR WEANERS – VARIETY AND PROCESSING

TRIAL REPORT NO. 949

Weaner productivity was not adversely affected by the addition of 8% conventional rapeseed cake to a starter diet and 15% to a weaner diet. Enlargement of thyroid gland and liver was observed when pigs were fed rapeseed.

INSTITUTION: PIG RESEARCH CNTRE

AUTHORS: HANNE MARIBO

CAROLINE KOLD NIELSEN

CATHRINE SAUER

PUBLISHED: JULY 25, 2012

Animals: Weaners & Finishers

Subject: Nutrition

Abstract

Cold-pressed rapeseed cake resulted in lower production value than conventionally pressed rapeseed cake. This was the only productivity difference found between the groups in this trial. The results show that weaners are not as sensitive to the use of rapeseed in feed as previously assumed as productivity was unaffected when 8% rapeseed cake was added to the starter diet and 15% to the weaner diet.

The effect on weaners of five different rapeseed products varying in processing and varieties was investigated according to the trial design shown in the table.

Group	1	2	3	4	5	6
Rape variety	Lioness	Lioness	Excalibur	Lioness	Lioness	Control, soya protein
Glucosinolate content in rapeseed cake	Low	Low	High	Low	Low	-
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing/ partial dehulling	-

Initially, all batches of rapeseed were analysed to find rapeseed with high and low glucosinolate content. Subsequently rapeseed cake was produced under different processing methods. Preliminary analyses demonstrated differences in content of crude fat, feed units (FUgp), lysine and glucosinolates. Variations in nutrient content must be taken into consideration when formulating diets containing rapeseed to ensure that the diets have optimum nutrient composition.

Depending on variety, glucosinolate content was either 10 or 23 µmol/g. The content of 4-hydroxy-glucobrassicin reveals the intensity of heat that the rapeseed was exposed to during processing and thereby the percentage of glucosinolates that were decomposed to antinutritional components. Analyses showed that intensive heat processing caused the content of 4-hydroxy-glucobrassicin to drop below the recommended level of 2 µmol/g, which is an indication that the rapeseed cake was damaged by the heat.

FINANCIAL SUPPORT
The project was financially supported by Innovation Act under the Ministry of Food, Agriculture and Fisheries of Denmark, Danish Pig Research Centre and the Pig Levy Fund. Project ID.: DSP/09/52. Journal no. 3412-07-01960-03.

Background

In recent years, the price of rapeseed oil has soared, and this has increased the interest in growing rapeseed as rapeseed oil may be used as a substitute for diesel oil after refining to biodiesel. An increase in rapeseed oil production will increase the production of rapeseed cake and rapeseed meal. The amino acid profile makes rapeseed protein a valuable source of protein for production of muscles/meat; its biological value is comparable to fish protein and potato protein. However, too high or too low temperatures during oil extraction and the content of glucosinolate, degradation products from glucosinolates and fibre in the rapeseed may affect the pig's utilization of the protein.

Today the so-called double-low varieties are grown in Denmark [8], i.e. they have low content of erucic acid and glucosinolates (EU definition in 2013: below 18 micromol/g rapeseed). Modern varieties contain 15-25 micromol glucosinolates/g, but during oil extraction glucosinolates may decompose to antinutritional compounds. This may also happen if myrosinase in the rapeseed is not inactivated by heat treatment during oil extraction. These products may be even more detrimental to the pigs' digestion than the glucosinolates [16]. Research has previously indicated that if heat treatment is performed under correct temperatures during oil extraction, it may just be possible to use large amounts of rapeseed (up to 24%) in feed for finishers [5]. Up to 11% entire rapeseeds may be used in finisher feed provided the glucosinolate content is 10 micromol/g [2], but if rapeseed cakes were damaged during heat treatment finisher productivity will be adversely affected [1]. Weaner feed may contain up to 15% rapeseed cake from Danish oil mills (Scanola, Emmelev and Danraps) provided that the nutrient content of the rapeseed cake is known and is optimized correctly in the diet. However, German and Polish rapeseed meal is known to reduce productivity [6].

Trials with rats, chicken and pigs show enlargement of the thyroid gland when they are fed rapeseed products with increasing glucosinolate content [14], [16]. Foreign studies have also indicated enlarged thyroid gland in pigs fed rapeseed products. In some cases, also liver enlargement was observed in pigs [17], [18], [19]. An enlarged thyroid gland is attributed to the fact that the antinutritional components from glucosinolates prevent deposition of iodine in the metabolism hormones T3 and T4 whereby the production of these hormones is inhibited. The thyroid gland compensates for this by increasing in size. This process is also seen in the liver where antinutritional compounds from glucosinolates, particularly nitriles, affect enzyme activity, and the liver compensates by increasing in size.

Blood analysis provides valuable information on organ function and pig health, and is therefore a valuable tool in assessing the nutritional value of rapeseed cake. Biochemical and haematological blood analyses will provide a good impression of the pigs' general health. A biochemical analysis includes recording of the blood concentration of, for instance, iron, protein and alanine aminotransferase, asparagine aminotransferase and creatine (enzymes). This analysis will provide information on organ function and will indicate if a pig suffers from, for instance, liver or kidney damage or muscle injuries [10], [11], [13]. A haematological analysis includes a count of red and white blood cells, which will provide information on infections and elevated immune response in the pigs [13]. Several factors, such as feed, productivity, health, age, gender, genetics and environment/housing, affect the haematological and biochemical blood values [7], [12].

This trial is part of a comprehensive project called "Optimisation of rapeseed cake for use as protein and energy source for monogastric animals, and development of new high-value protein products" made in cooperation between the Faculty of Science, University of Copenhagen; the Faculty of Agricultural Sciences, Aarhus University; DLA Agro; Scanola A/S; and Pig Research Centre.

The aim of the trial was to characterize rapeseed products produced from different varieties and under to different types of processing in terms of protein, fat, energy and glucosinolates, and to analyse the effect of these products on weaner productivity and physiology.

Material and method

The trial was conducted in the weaner sections at experimental station Grønhøj. The pigs entered the trial at weaning at approx. 5 weeks of age when they were fed the starter diet. Start weight averaged 7.3 kg. Two weeks later, at an average weight of 10.1 kg, the pigs switched to the weaner diet. End weight averaged 30.6 kg. The trial comprised six groups according to the trial design shown in table 1.

Table 1. Trial design and processing of rapeseed products.

Group	1	2	3	4	5	6
Variety	Lioness	Lioness	Excalibur	Lioness	Lioness	Control with soy protein
Glucosinolate content in rapeseed cake	Low	Low	High	Low	Low	-
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing/ partial dehulling	-

Rapeseed cake

All batches of rapeseed were analysed for glucosinolates, and based on the outcome (appendix 1) rapeseeds were assigned to different processing and trial groups (figure 1). The rapeseed was purchased for the trial: the rapeseed for groups 1-3 was processed by Scanola A/S in Denmark, and the rapeseed for groups 4 and 5 were processed in a small test facility. Dehulling, which was revealed not to be optimum, took place at a small test facility. The rapeseed cake was subsequently analysed for content of nutrients and glucosinolates. Nutrient content was used in the formulation of the trial diets. Collection and splitting of all samples followed the TOS principles [9]. Appendix 1 shows the nutrient content of the rapeseed cake used.

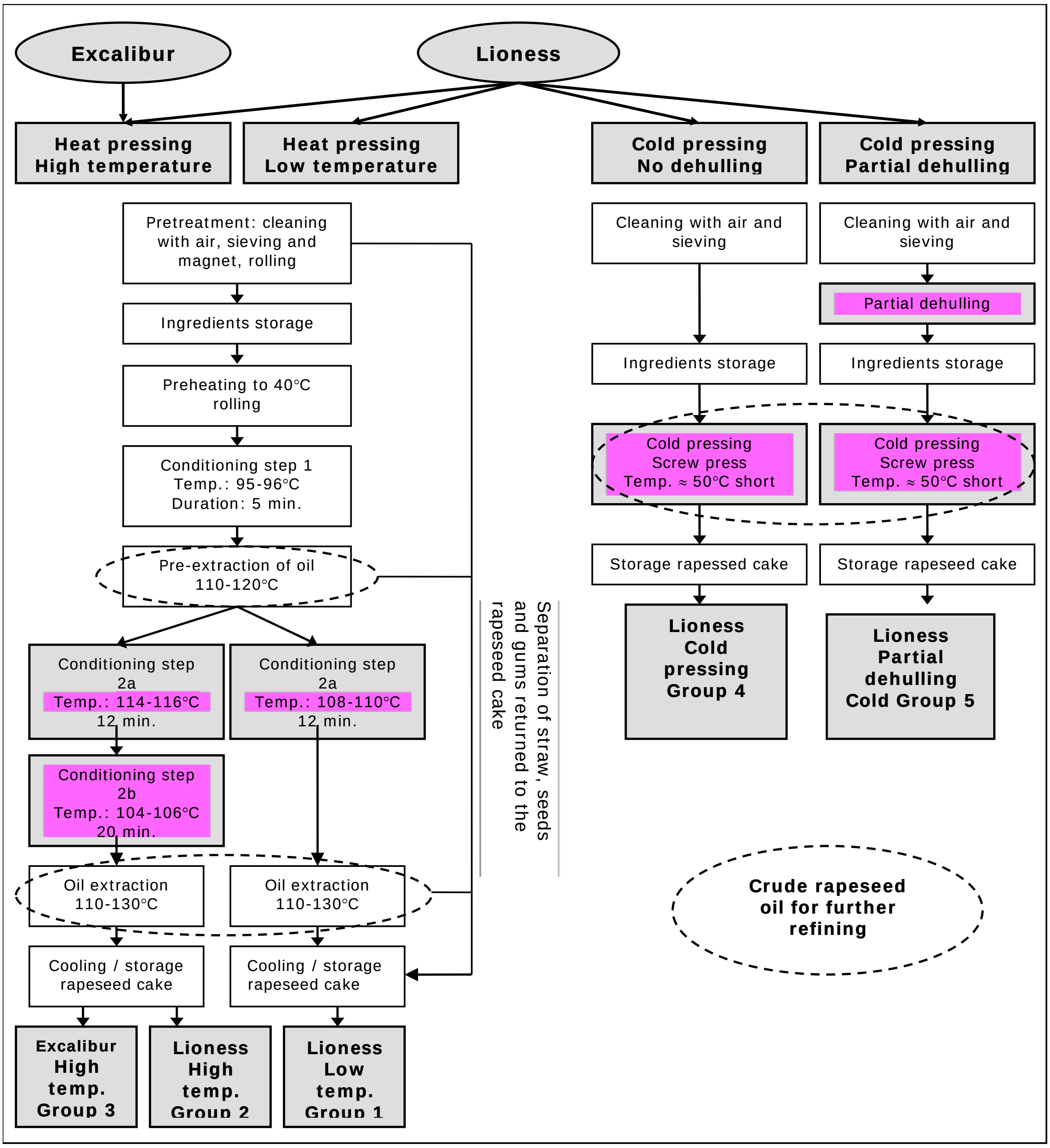

Figure 1. Processing of rapeseed. The pink colour illustrates the in processing between the groups. All batches of rapeseed cakes were produced form the two same batches of rapeseed.

Feed and diets

All pigs were fed ad lib from dry feeders, and in the first two weeks post-weaning they were given 2,500 zinc (prescribed by the vet). After ten days on the starter diet, a gradual switch was made over four days to the weaner diet.

The rapeseed cake contributed with the same crude protein content in the starter diets and the weaner diets (25.6 g/kg and 46.1 g/kg, respectively). The diets were formulated to have identical nutrient content. The content of the first five essential amino acids was 5% above the standards, and calcium and phosphorus content was 10% above the standards [3] to prevent variations in the content of other ingredients from affecting the nutrient content and thereby the outcome of the trial. Appendix 2 provides an outline of diet composition, and the nutrient content of the diets is shown in appendix 3.

The nutrient content in the feed for group 5 deviated from the rest as protein and amino acid content was higher than in the other diets. This was necessary to be able to comply with the requirement that all rapeseed products contribute with equal protein content as the cold-pressed rapeseed cake used in group 5 deviated from the other types of rapeseed cake used in the trial. The diets were produced by Danish Agro in Janderup. Content of glucosinolates and myrosinase in the rapeseed products was analysed by the Department of Basic Sciences and Environment at the Faculty of Science, University of Copenhagen (Heidi Blok Frandsen).

Table 2. Content in % of rapeseed cake and soybean meal in the diets, first and second batches (after new harvest).

Group	1	2	3	4	5	6.
Glucosinolate content	Low	Low	High	Low	Low	Control
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing/ partial dehulling	-
Starter diet						
Rapeseed	8.6	8.4	8.4	9.8	10.0	-
Soybean meal	7.0	7.0	7.0	7.0	7.0	7.0
Soy protein concentrate	10.0 (9.3)	9.9	10.0	10.0	10.0	13.1
Weaner diet						
Rapeseed	15.5	15.1	15.1	17.4 (17.7)	18.0	-
Soybean meal	17.5 (15.3)	17.3 (14.1)	17.4 (14.3)	17.7 (17.1)	18.3 (18.6)	17.5
Soy protein concentrate	-	-	-	-	-	5.7 (5.0)

Weight of organs and blood sample analyses

Six randomly selected pigs from groups 1, 2, 3, 4 and 6 (30) were destroyed in order to weigh their organs and collect blood samples for analysis of the effect of the diets on the pigs' physiology. The pigs were destroyed when they were 68 or 75 days old and weighed averagely 28.2 kg ±4.7 kg. The live weight of each pig was recorded before they were destroyed with a captive bolt pistol and subsequently exsanguinated. Two blood samples from each pig (2 x 10 ml) were subject to biochemical and haematological analyses at the laboratory at the University Hospital of the University of Copenhagen. Subsequently, thyroid gland, liver, kidneys, adrenal glands, heart, lungs and spleen were weighed.

Statistics

Daily gain and feed conversion ratio were used to calculate the production value per pig (PV) at the same feed prices.

Production value/pig = PV = (sales price ÷ purchase price ÷ feed costs)/productive days

Calculation of the production value is based on:
Average pig price of five years (September 1, 2006, to September 1, 2011)

- 7 kg pigs: DKK 193/pig + DKK 9.47 per kg in the period 5-7 kg
- 30 kg pigs: DKK 331/pig ÷ DKK 5.72 per kg in the period 15-30 kg
- Feed prices: Starter diet DKK 3.06 per feed unit; weaner diet DKK 1.77 per feed unit
- Various costs: DKK 20
- Value of gain: DKK 6.00 per kg

The trial design included the following comparisons:

- Trial groups 1-5 vs control
- Effect of variety (group 2 with group 3)
- Effect of processing (group 1 with 2 and 4)

The production value was analysed as primary parametre based on feed conversion ratio and daily gain. Mortality and disease were analysed as secondary parametres. Continuous data were described in a generalised model with group as systematic effect, weight at trial start as co-variable and block as random effect. Discrete data (mortality and treatments) were described with logistic regression with treatment as explanatory variable. Results are shown as corrected average for each group; Bonferroni corrections were made for five comparisons in pair. Data were tested for normal distribution, interaction and outliers to ensure that no pens deviated significantly from other pens.

Data for blood samples and organ weight were analysed for each individual pig in the MIXED procedure in SAS with treatment as primary effect and replicate as random effect. Statistical analyses included the relative organ weight (g/k live weight).

Results and discussion

Rapeseed

Glucosinolate content was lower in the rapeseed cake used in group 2 due to intensive heat during processing. In group 1, the processing temperature was approx. 6°C lower and duration of processing approx. 20 minutes shorter than in groups 2 and 3 (high temperature). The difference in processing temperature was lower than planned. The content of 4-hydroxy-glucobrassicin dropped as a consequence of the high processing temperature in groups 2 and 3. The content was below 20 µmol/g oil-free rape seed cake, which is the limit for heat treatment.

Oil content (measured as crude fat) in cold-pressed rapeseed cake was significantly higher than in rapeseed subjected to heat processing. Myrosinase was still active in the cold-pressed rapeseed cake as the temperature was not sufficiently high to inactivate myrosinase. The content of protein, energy and amino acids is shown in appendix 1.

Table 3. Nutrient content of rapeseed cake after processing.*

Group	1	2	3	4	5
Glucosinolate content in rapeseed, µmol/g	10.7	10.7	24.3	10.7	10.7
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing Dehulling
Crude fat, %	11,7	11,2	10,9	24,3	27,2
Glucosinolate content in rapeseed cake, µmol/g	13,1	10,2	23,3	12,4	11,6
4-hydroxy-glucobrassicin, µmol/g rapeseed cake	3,8	1,4	0,7	4,0	3,1
Myrosinase activity	-	-	-	+	+

* Average of four analyses. Glucosinolate content is the average of three analyses.

Feed

Analyses of nutrients in the weaner diets for groups 1-5 demonstrated good agreement between the declared and analysed nutrient content (appendix 2). The lowest lysine content was found in the control diet: 13.2 g/kg vs 14.0-14.5 g/kg in the trial diets, corresponding to a difference of 0.8 g st.dig. lysine per feed unit. This has probably only affected production value slightly as the lysine content of the control diet was 2% above the standard. The content of calcium and phosphorus was lower than calculated. Calcium content varied from 3 to 12% below the standard in the starter diet, which the pigs were fed the first 14 days, and this is not thought to have affected the overall growth period. In the weaner diet, calcium content was level with or above the standard. Phosphorus content was 4-12% below the declared content in both the starter diet and the weaner diet, but this is not believed to have affected the outcome as the diets were formulated to have a content of 10% above the standard.

The highest content of glucosinolates was found in the diet for group 3 due to the increased content of rapeseed and rapeseed cake. As expected, the highest content of 4-hydroxy-glucobrassicin was found in the diets containing rapeseed cake processed at the lowest temperatures. Heat treatment during pelleting reduced glucosinolate content by approx. 50% compared with the calculated content.

Myrosinase activity was only found in the diets containing cold-pressed rapeseed cake (groups 4 and 5). This indicates that the pelleting process at the feed mill is not enough to inactivate myrosinase, and myrosinase may thereby have decomposed glucosinolates to antinutritional components in the rapeseed cake as well as in the feed. However, analyses did not reveal a significant decomposition in the feed, which may be attributed to the fact that there was not enough water in the pelleted feed to activate myrosinase.

The highest crude fibre content was found in the trial diets. There were no differences between groups 4 and 5 with and without dehulling, respectively, which indicates that the dehulling process was not optimum (appendix 3).

Health

Analyses showed no differences between the groups in mortality or treatments for diarrhoea. Treatment for diarrhoea averaged 0.9 day per pig. Mortality averaged 0.6%, and 5.6% were moved to a hospital pen during the trial.

Weight of organs and blood sample analyses

Liver weight was significantly (p=0.01) affected by the feed, and enlarged liver was seen in all trial groups. The largest changes were observed in group 2 where liver weight was 32.1 g/kg live weight vs 25.9 g/kg live weight in the control group. The thyroid gland in the trial pigs was not significantly enlarged compared with control, though there was a tendency (p=0.08) to enlarged thyroid gland in groups 1, 2 and 4 compared with control. The weight of the remaining organs was not affected by the different trial treatments (table 4).

Table 4. Organ weight, g/kg live weight.

Group	1	2	3	4	Control	P-value
Glucosinolate content in rapeseed	Low	Low	High	Low	-	
Processing	Low temp.	High temp.	High temp.	Cold pressing	-	-
Live weight, kg	26.2	28.2	28.9	27.7	30.0	0.42
Organ weight						
Thyroid gland, mg/kg live weight	163	159	140	158	116	0.08
Liver, g/kg live weight	29.7[a]	32.1[a]	30.7[a]	29.9[a]	25.9[b]	0.01
Kidneys, g/kg live weight	5.1	5.4	5.6	5.1	4.9	0.24
Adrenal glands, mg/kg live weight	100	115	111	118	103	0.61
Lungs, g/kg live weight	16.1	15.6	13.2	15.7	15.1	0.41
Heart, g/kg live weight	5.9	6.0	5.3	5.2	5.3	0.26
Spleen, g/kg live weight	2.1	1.7	1.6	1.8	1.6	0.27

ab) Different superscripts indicate significant difference ($p < 0.05$) from control.

Results of blood sample analyses are shown in table 5. Creatine concentration was significantly reduced ($p<0.05$) in groups 1 and 2 compared with control, and the concentration was lower in group 2 than in group 3. Low concentrations of creatine, which is a liver enzyme, may indicate liver damage or reduced liver function. Consequently, the biochemical analysis indicates that the pigs in groups 1 and 2 may have suffered from reduced liver function compared with the control pigs. Reduced liver function may be the result of an enlarged liver, which was observed in groups 1 and 2. The content of iron in the blood was significantly affected by variety and thereby by the content of glucosinolate in the rapeseed, ie. the pigs in group 2 had a lower content of iron in the blood than the pigs in group 3. The blood values of the pigs in this trial were generally within the interval normally seen for pigs in this age group in other trials [7], [12].

Table 5. Biochemical and haematological blood values.

Group	1	2	3	4	Control	P-value				
Glucosinolate content, rapeseed	Low	Low	High	Low	-	Overall	1 vs 2	2 vs 3	4 vs 1	4 vs 2
Processing	Low temp.	High temp.	High temp.	Cold press.	-	-	-	-	-	-
Biochemical analysis										
Creatinine, umol/L	63.8^{a}	61.4^{a}	68.4^{b}	67.7^{b}	71.4^{b}	0.05	0.50	0.05	0.27	0.08
Iron, umol/L	31.1^{ab}	23.4^{b}	34.5^{a}	23.7^{ab}	27.7^{ab}	0.04	0.07	0.01	0.08	0.96
Carbamide, mmol/L	2.4	2.4	3.1	2.8	2.7	0.11	-	-	-	-
Albumin, g/L	34.6	35.9	38.5	36.5	37.0	0.45	-	-	-	-
Alkaline phosphatase, U/L	688	595	625	663	622	0.63	-	-	-	-
ALAT[1], U/L	65.3	56.4	67.2	62.0	63.0	0.57	-	-	-	-
ASAT[2], U/L	85.3	82.9	94.6	88.9	113.4	0.80	-	-	-	-
Haematological analysis										
White blood cells, 10^{9}/L	21.0	19.0	19.2	22.8	18.0	0.46	-	-	-	-
Red blood cells, 10^{12}/L	6.2	6.4	6.5	6.9	6.1	0.12	-	-	-	-
Haemoglobin, mmol/L	6.9	6.9	7.2	7.2	7.2	0.74	-	-	-	-
Neutrofile leukocytes, 10^{9}/L	10.6	8.5	8.3	10.9	6.4	0.18	-	-	-	-
Lymphocytes, 10^{9}/L	8.8	8.7	9.0	9.4	10.2	0.84	-	-	-	-
Monocytes, 10^{9}/L	1.1	1.0	0.9	1.3	1.0	0.45	-	-	-	-
Eosinofile leukocytes, 10^{9}/L	0.7	0.5	0.7	0.8	0.6	0.08	-	-	-	-

ab) Different superscripts indicate significant difference ($p < 0.05$) from control.

1) Alanine aminotransferase. 2) Asparagine aminotransferase

Productivity

Production (i.e. gross margin) value was not affected by glucosinolate content/variety (group 2 vs 3). However, an effect was observed of heat treatment (group 1 vs 2) as heat treatment (group 1) at a lower temperature resulted in a lower production value despite a lower glucosinolate content in the feed. Cold pressing did not affect the production value even though myrosinase activity was detected in these diets (table 6). Compared with control, productivity was lower in group 1 with low glucosinolate content and low processing temperature. No differences were observed between control and the remaining trial groups.

Table 6. Productivity and production value at identical feed prices.

Group	1	2	3	4	5	6
Glucosinolate content in rapeseed cake	Low	Low	High	Low	Low	Control
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing/ Dehulling	-
Trial start to intermediate weighing 7.0-10.1 kg						
Daily gain, g/day	219	215	219	216	219	213
Feed intake, FUgp/day	0.34	0.33	0.33	0.32	0.33	0.34
FCR, FUgp/kg	1.61	1.56	1.57	1.54	1.51	1.63
PV	0.36	0.37	0.37	0.41	0.40	0.33
Intermediate weighing until departure 10.1-30.6 kg						
Daily gain, g/day	611	613	631	603	589	637
Feed intake, FUgp/day	1.12	1.07	1.10	1.05	1.01	1.13
FCR, FUgp/kg	1.84	1.75	1.76	1.75	1.73	1.78
PV	1.89	1.99	2.03	1.95	1.96	2.05
Entire trial period 7.0-30.6 kg						
Daily gain, g/day	495	496	508	488	480	510
Feed intake, FUgp/day	0.89	0.85	0.87	0.83	0.81	0.89
FCR, FUgp/kg	1.80	1.72	1.73	1.71	1.69	1.75
Production value, DKK/pig/day[1]	1.44	1.51	1.55	1.50	1.50	1.54
Index[1]	94[a]	99[ab]	101[ab]	97[ab]	98[ab]	100[ab]

ab Different superscripts indicate significant difference ($p < 0.05$) from control.

1) For the production to differ significantly simply by comparing control with the trial groups there must be a minimum difference in production value of DKK 0.07 per pig corresponding to 4.6 index points.

Discussion

General

Overall, the use of rapeseed in both starter and weaner diets did not adversely affect the production value with the exception of group 1 in which production value was lower than in the control group. This shows that it is possible to add up to 8% rapeseed cake to starter diets and up to 15% in weaner diets.

All the pigs fed rapeseed cake had enlarged liver, and there was a tendency to enlarged thyroid gland in groups 1, 2 and 4 compared with control. There were no differences in liver/blood parametres between the groups.

Temperature

Only a small difference in temperature was achieved during processing, and the rapeseed cake used in groups 1 and 2 had a low content of glucosinolates. Contrary to expectations, the pigs fed the diet that was processed at the lowest temperature had a numerically lower production value. The production value of the pigs fed cold-pressed rapeseed did not differ from that of the pigs fed heat-treated rapeseed. It is generally not recommended to use cold-pressed rapeseed as reduced inactivation of myrosinase may adversely affect productivity. Myrosinase activity also depends on the presence of liquid.

Variety

The production value did not differ between groups 2 and 3 where two different varieties with different glucosinolate content were used. This may be explained by the fact that the processing was so gentle that only few antinutritional compounds formed during heat treatment and that the variations in the remaining intact glucosinolates did not affect weaner growth. Analyses of myrosinase activity demonstrated that heat treatment did inactivate myrosinase, and this is probably the reason why no antinutritional compounds formed in the feed.

Weaners in this trial were fed the diets for a limited period only, and this did not adversely affect productivity. Foreign research indicates that weaners tolerate glucosinolates better than finishers [20], probably because finishers have a larger intake of glucosinolates over a longer period of time. This was confirmed by a Danish study where production value dropped when 10% rapeseed cake was added to finisher feed [15].

Generally, it would be ideal if a rapeseed cake low in glucosinolate (in the original seed) was available and if gentle processing during oil extraction was a requirement.

Cold pressing

During cold pressing, the temperature did not exceed 50°C, which is the reason why myrosinase was not inactivated during oil extraction. Myrosinase activity was also found in the feed, and this indicates that the temperature during pelleting was not enough to inactivate myrosinase. However, inadequate inactivation of myrosinase did not lead to differences in blood parametres or organ weight between group 4 and the other groups. The only negative effect of cold pressing was a reduced feed intake – probably due to an increased content of bitter tasting antinutritional compounds from glucosinolates.

Organs and blood parametres

Analyses revealed only small differences between the groups in organ weight and blood parametres. However, compared with control, the liver of pigs fed rapeseed weighed 15-24% more and there was a tendency to enlarged thyroid gland. The pigs in groups 1 and 2 (low glucosinolate content and low and high processing temperatures, respectively) had a lower concentration of creatine in the blood, which is an indication of reduced liver function. However, all blood values were within the intervals normally recorded in trials [7], [12]. The outcome of this trial confirms findings of previous trials that pigs fed rapeseed products have enlarged thyroid gland and liver [14], [17], [18], [19]. However, in this trial no direct correlation was found between enlarged organs and productivity, which indicates that the organs maintained their function through enlargement.

Dehulling

The dehulling process was not satisfactory, and the content of crude fibre was the same in the starter diet and the weaner diet in groups 4 and 5 (cold-pressed, with and without dehulling). Productivity did not differ between groups 4 and 5.

Conclusion

The production value dropped when rapeseed cake was processed under low temperatures. There were no differences between the other groups regardless of variety (glucosinolate content) and cold pressing. Weaners are not as sensitive towards high glucosinolate content as previously assumed as productivity as unaffected by inclusion of 8% rapeseed cake in the starter diet and 15% in the weaner feed.

References

[1] **Hansen, C.F.** (2000): Stigende mængder rapsskrå til slagtesvin. Meddelelse nr. 463. Landsudvalget for Svin.

[2] **Tybirk, P. & N.O. Nielsen** (1994): Rapsfrø i slagtesvinefoder. Erfaring nr. 9422. Landsudvalget for Svin.

[3] **Tybirk, P. & L. Jørgensen** (2008): Normer for Næringsstoffer. Videncenter for Svineproduktion.

[4] **Maribo, H., C. Claudi-Magnussen & T. Jacobsen** (2006): Fedtkilder til slagtesvin. Notat nr. 0614. Dansk Svineproduktion.

[5] **Just, A., V. Hansen, A. Jensen, C. Mikkelsen, O. Olsen & H. Sørensen** (1982): Rapsskrå (Line) som delvis eller fuld erstatning for sojaskrå i slagtesvins foder. Meddelelse nr. 402. Statens Husdyrbrugsforsøg.

[6] **Maribo, H.** (2010): Smågrisefoder tilsat 15 pct. rapskage eller –skrå. Meddelelse nr. 890. Videncenter for Svineproduktion.

[7] **Friendship, R.M., J.H. Lumsden, I. McMillan og M.R. Wilson.** (1984): Hematology and Biochemistry Reference Values for Ontario Swine. Can. J. Comp. Med. 48:390-393.

[8] Sortsinfo (2011): Videncentret for Landbrug, www.VFL.dk.

[9] **Esbensen, K.H. et al.** (2002): Sampling del I, II, III, IV, V. Dansk Kemi, 83 nr. 9, 10,11,12 samt 84 nr. 4, 2003.

[10] **Thorup, F., H. Pedersen og A.K. Olesen** (2010): Sodødelighed i farestalden. Meddelelse nr. 886. Videncenter for Svineproduktion.

[11] **Busch, M.E. og P. Bækbo** (2001): Farefeber – blodværdier hos syge og raske søer. Meddelelse nr. 516. Videncenter for Svineproduktion.

[12] **Klem, T.B., E. Bleken, H. Morberg, S.I. Thoresen, T. Framstad** (2010): Hematologic and biochemical reference intervals for Norwegian crossbreed grower pigs. Veterinary Clinical Pathology 39:2, side 221-226.

[13] Lægehåndbogen (2009): Danske Regioner, www.laegehaandbogen.dk.

[14] **Jensen, S.K.** (2011): Quality demands for present and future optimal nutritional value of rapeseed for feed purposes. In: Proceedings 13th International Rapeseed Congress. June 5-9 2011, Prague Congress Center, Czech Republic. Plenary lecture, 10-12. ISBN 978-87065-33-4, 1532pp.

[15] **Hansen, S.** (2011): Høj iblanding af rapskage og solsikkeskrå til slagtesvinefoder forringede slagtesvinenes produktivitet. Meddelelse nr. 914. Videncenter for Svineproduktion.

[16] **Jensen, SK, Young-Gang Liu, B.O. Eggum** (1995): The effect of heat treatment on glucosinolates and nutritional value of rapeseed meal in rats. Anim. Feed Sci & Techonl. 53, pp 17-28.

[17] **Schone, F., F. Tischendorf, M. Leiterer, H. Hartung & I. Bargholz** (2001): Effects of rapeseed press cake glucosinolates and iodine on the performance, the thyroid gland and the liver vitamin A status of pigs. Archives of Animal Nutrition-Archiv Fur Tierernahrung. Vol 55:4, side 333-350.

[18] **Spiegel, C., G. Bestetti, G. Rossi & J.W. Blum** (1993): Feeding of rapeseed presscake meal to pigs: effects on thyroid morphology and function and on thyroid hormone blood levels, on liver and on growth performance. Journal of Veterinary Medicine. Series A. Vol 40:1, side 45-57.

[19] **Thomke, S., H. Pettersson, M. Neil & J. Hakansson** (1998): Skeletal muscle goitrin concentration and organ weights in growing pigs fed diets containing rapeseed meal. Animal Feed Science and Technology. Vol. 73:3/4, side 207-215.

[20] **Roth-Meier, D.A., Böhmer, B.M., Roth, F.X.** (2004): Effects of feeding canola meal and sweet lupin in amino acid balanced diets on growth performance and carcass characteristics of growing pigs. Anim. Res. 53 pp. 21-34.

Participants

Technical support: Jens Ove Hansen & Per Mark Hagelskjær, Pig Research Centre

Statistical support: Mai Britt Nielsen, Pig Research Centre

Trial no. 1093

//NJK//

Appendix 1

Rapeseed tested for the trial. Total glucosinolate content (micromol/g), average of 3 anlayses.

Variety	Total glucosinolate content	Selected for the trial
Excalibur	24.3	Group 3
Lioness	10.7	Groups 1, 2, 4, 5
Astrid	17.8	Not selected
Mix	12.9	Not selected

Analysed content of nutrients and glucosinolates in rapeseed cakes used.

Group	1	2	3	4	5
Glucosinolate content in rapeseed, µmol/g oil-free seeds	19.8	19.8	45.0	19.8	19.8
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing / Dehulling
FUgp/100 kg [1]	96	96	95	137	152
Crude protein, % [1]	29.7	30.5	30.5	26.0	25.6
Crude fat, % [1]	11.7	11.2	10.9	24.3	27.2
Ca, g/kg [2]	7.1	7.4	5.3	6.4	5.8
P, g/kg[2]	9.8	9.9	10.0	8.5	8.5
Lysine, g/kg [1]	16.6	16.0	16.9	15.1	14.7
Methionine, g/kg	5.7	5.8	6.0	5.0	4.9
Cystine, g/kg	6.0	5.9	7.1	5.4	5.4
Threonine, g/kg	14.1	14.3	13.8	12.4	12.1
Glucosinolate content in rapeseed cake, µmol/g rapeseed cake	13.1	10.2	23.3	12.4	11.6
4-hydroxy-glucobrassicin, µmol/g rapeseed cake	3.8	1.4	0.7	4.0	3.1

1) Average of 4 analyses.

2) Average of 9 analyses.

Appendix 2

Ingredients, starter diets (7-10 kg), first and second deliveries, % (new harvest).

Group	1	2	3	4	5	6
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing / Dehulling	Control
Rapeseed cake	8.6/8.6	8.4/8.4	8.4/8.4	9.8/9.8	10.0/10.0	-
Wheat	37.9/39.1	38.2/39.3	38.0/39.2	38.0/39.3	38.8/40.0	43.4/44.6
Barley	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0
Dehulled soybean meal	7.0/7.0	7.0/7.0	7.0/7.0	7.0/7.0	7.0/7.0	7.0/7.0
Soya protein conc. HP 200	10.0/9.3	9.9/9.2	10.0/9.2	10.0/9.3	9.9/9.2	13.1/12.4
Fish meal	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0	5.0/5.0
Dried whey	6.0/6.0	6.0/6.0	6.0/6.0	6.0/6.0	6.0/6.0	6.0/6.0
Potato protein	1.5/1.5	1.5/1.5	1.5/1.5	1.5/1.5	1.5/1.5	1.5/1.5
Vegetable oil	3.8/3.8	3.8/3.8	3.8/3.8	3.8/3.8	3.8/3.8	3.5/2.9
Molasses,sugar beet	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0
Dietary salt	0.3/0.3	0.3/0.3	0.3/0.3	0.3/0.3	0.3/0.3	0.3/0.3
Calcium carbonate	0.8/0.8	0.8/0.8	0.8/0.8	0.8/0.8	0.8/0.8	0.9/0.9
Mono calcium phosphate	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.2/1.2
Phyzyme XP, 4000 TPT	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01
Threonine	0.11/0.12	0.12/0.12	0.12/0.13	0.11/0.12	0.11/0.12	0.13/0.15
Methionine	0.10/0.11	0.10/0.11	0.10/0.11	0.10/0.11	0.10/0.10	0.13/0.14
Lysine	0.39/0.41	0.40/0.42	0.39/0.41	0.38/0.40	0.38/0.41	0.39/0.41
Tryptophan	0.05/0.04	0.05/0.04	0.05/0.04	0.05/0.04	0.05/0.04	0.05/0.04
Benzoic acid	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0
Vitamin premix	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5
Microgrits (colouring agent)	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	-	0.05/0.05

Ingredients, weaner diets (10-30 kg), first and second deliveries, % (new harvest).

Group	1	2	3	4	5	6
Processing	Low temp.	High temp.	High temp.	Cold pressing	Cold pressing / Dehulling	Control
Rapeseed cake	15.5/15.5	15.1/15.1	15.1/15.1	17.7/17.7	18.0/18.0	-
Wheat	40.6/42.0	41.1/43.1	40.9/42.8	40.9/41.6	40.3/39.7	50.4/51.1
Barley	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0	15.0/15.0
Dehulled soybean meal	17.5/15.3	17.3/14.1	17.4/14.3	17.4/17.1	18.3/18.9	17.5/17.5
Soya proteinconc. HP 200	-	-	-	-	-	5.7/5.0
Vegetable oil	3.3/2.8	3.3/2.7	3.4/2.9	0.8/0.4	0.3/0.3	2.8/24.
Potato protein	2.0/2.8	2.0/3.4	2.0/3.3	2.0/1.8	2.0/1.5	2.0/2.0
Molasses, sugar beet	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0
Dietary salt	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.5
Calcium carbonate	1.5/1.6	1.5/1.6	1.5/1.6	1.5/1.6	1.5/1.6	1.6/1.7
Mono calcium phosphate	1.1/1.4	1.1/1.4	1.1/1.4	1.1/1.4	1.2/1.4	1.4/1.6
Phyzyme XP, 4000 TPT	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01	0.01/0.01
Threonine	0.08/0.09	0.09/0.08	0.09/0.09	0.08/0.09	0.08/0.10	0.12/0.13
Methionine	0.11/0.11	0.11/0.11	0.11/0.11	0.11/0.12	0.11/0.12	0.14/0.15
Lysine	0.43/0.44	0.44/0.45	0.43/0.44	0.42/0.44	0.42/0.45	0.43/0.46
Tryptophan	0.03/0.03	0.03/0.03	0.03/0.03	0.03/0.03	0.03/0.03	0.03/0.03
Benzoic acid	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0	1.0/1.0
Vitamin premix	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4	0.4/0.4
Microgrits (colouring agent)	0.05/0.05	0.05/0.05	0.05/0.05	0.05/0.05	-	0.05/0.05

Appendix 3

Analyses of nutrient content in starter diets (average of two deliveries and four analyses).

Group	1		2		3	
	Calculated	Analysed	Calculated	Analysed	Calculated	Analysed
FUgp/100 kg	116	117	116	117	116	118
Crude protein, %	21.0	20.5	21.0	21.1	21.0	21.2
Crude fat, %	6.0	6.6	6.0	6.8	6.0	6.9
Crude fibre, %[1]	3.6	3.8	3.6	3.9	3.6	4.0
Calcium, g/kg	8.3	6.7	8.3	7.3	8.3	7.4
Phosphorus, g/kg	7.2	6.2	7.2	6.7	7.2	6.8
Lysin, g/kg	14.8	14.4	14.8	14.5	14.8	14.8
Methionin, g/kg	4.7	4.5	4.6	4.7	4.7	4.7
Cystin, g/kg	3.4	3.3	3.4	3.3	3.4	3.4
Meth+Cys, g/kg	8.1	7.8	8.0	7.9	8.1	8.1
Threonine, g/kg	9.3	9.0	9.3	9.2	9.3	9.4
Phytase activity, FTU[2]	500	778	500	891	500	835

1) 1 analysis.

2) Average of 2 analyses.

Group	4		5		6	
	Calculated	Analysed	Calculated	Analysed	Calculated	Analysed
FUgp/100 kg	116	117	116	116	116	118
Crude protein, %	21.0	21.7	21.0	21.6	21.0	20.5
Crude fat, %	6.0	6.7	5.7	6.0	6.0	5.7
Crude fibre, %[1]	3.7	3.6	3.8	3.5	3.6	3.0
Calcium, g/kg	8.3	7.4	8.3	7.3	8.3	7.1
Phosphorus, g/kg	7.2	6.8	7.2	6.6	7.1	6.3
Lysine, g/kg	14.8	14.9	14.8	15.0	14.8	14.1
Methionine, g/kg	4.6	4.7	4.6	4.6	4.6	4.7
Cystine, g/kg	3.5	3.4	3.6	3.4	3.6	3.2
Meth+Cys, g/kg	8.1	8.1	8.2	8.1	8.2	8.0
Threonine, g/kg	9.3	9.5	9.3	9.4	9.3	8.8
Phytase activity, FTU[2]	500	924	500	959	500	656

1) 1 analysis.

2) Average of 2 analyses.

Analyses of nutrient content in weaner diets (average of three deliveries and six analyses).

Group	1		2		3	
-	Calculated	Analysed	Calculated	Analysed	Calculated	Analysed
FUgp/100 kg	111	111	111	109	111	110
Crude protein, %	19.7	20.0	19.7	20.0	19.7	19.9
Crude fat, %	6.2	6.8	6.0	6.5	6.0	6.6
Crude fibre, %[1]	6.5	4.2	4.1	4.1	4.1	4.4
Calcium, g/kg	10.3	9.3	10.3	9.3	10.3	9.1
Phosphorus, g/kg	7.1	6.8	7.1	6.8	7.1	6.9
Lysine, g/kg	13.8	14.0	13.7	14.1	13.8	14.3
Methionine, g/kg	4.2	4.2	4.2	4.2	4.2	4.3
Cystine, g/kg	3.5	3.5	3.7	3.5	3.7	3.6
Meth+Cys, g/kg	7.7	7.6	7.9	7.7	8.0	7.9
Threonine, g/kg	8.6	8.9	8.6	8.9	8.6	8.9
Phytase activity, FTU[2]	500	970	500	955	500	1,034

1) 1 analysis.

2) Average of 3 analyses.

Group	4		5		6	
-	Calculated	Analysed	Calculated	Analysed	Calculated	Analysed
FUgp/100 kg	111	110	111	106	111	112
Crude protein, %	19.7	20.1	20.2	20.8	19.1	19.1
Crude fat, %	6.3	6.3	6.9	5.7	4.2	4.9
Crude fibre, %[1]	4.5	4.1	4.6	4.0	3.0	2.7
Calcium, g/kg	10.3	9.7	10.6	10.0	10.3	9.1
Phosphorus, g/kg	7.1	7.3	7.3	7.6	6.9	6.5
Lysine, g/kg	13.8	14.3	14.1	14.5	13.3	13.2
Methionine, g/kg	4.2	4.3	4.3	4.4	4.2	4.1
Cystine, g/kg	3.8	3.6	3.9	3.7	3.2	3.2
Meth+Cys, g/kg	8.0	8.0	8.2	8.2	7.3	7.3
Threonine, g/kg	8.6	9.2	8.8	9.3	8.2	8.4
Phytase activity, FTU[2]	500	1,012	500	774	500	794

1) 1 analysis.

2) Average of 3 analyses.

Content of glucosinolates and 4-hydroxy-glucobrassacin (µmol/g) in the diets.

Group		1	2	3	4	5
Starter diet[1]	Glucosinolate content	0.52	0.46	1.14	0.68	0.31
	4-hydroxy-glucobrassicin (% of glucosinolates)	0.01 (2)	0.02 (4)	0.01 (1)	0.05 (7)	0.08 (26.)
Weaner diet[2]	Glucosinolate content	1.32	1.27	2.70	0.53	0.95
	4-hydroxy-glucobrassicin (% of glucosinolates)	0.04 (3)	0.03 (2)	0.01 (0)	0.05 (9)	0.07 (8)

1) Groups 1-4: Average of two analyses. Group 5: 1 analysis.

2) Groups 1-4: Average of three analyses. Group 5: 1 analysis.

VIDENCENTER FOR SVINEPRODUKTION

Tlf.: 33 39 40 00

Fax: 33 11 25 45

vsp-info@lf.dk