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Fermented rapeseed for weaners

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Production value dropped by 7-9% in weaners (9-30 kg) fed fermented rapeseed compared with soybean meal and rapeseed cake. Trial results revealed poorer FCR and lower gain, and no effect on health.

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Abstract

The effect on productivity of fermented rapeseed cake from the manufacturer 'Fermentationsexperts A/S' was investigated in weaners in the weight interval 9-30 kg. Results revealed that production value dropped by 7% in weaners fed 15% fermented rapeseed cake compared with control (15% soybean meal) and by 9% compared with the pigs fed regular rapeseed cake. There was no significant difference in production value between the control pigs and the pigs fed regular rapeseed cake. The pigs fed fermented rapeseed cake had a lower gain and a poorer FCR. In practice, the feed containing fermented rapeseed must cost DKK 11 less per 100 FUgp for Danish pig producers to be able to cover the loss in productivity (ie € 1.3 less per 100 kg).

The reduced productivity may be attributed to several factors:

- Glucosinolate degradation products may have formed in the rapeseed used that adversely affected pig growth.
- Crude protein digestibility was set to 85% in the fermented rapeseed cake, and this may have been too high whereby not enough free amino acids were added to the diet. Digestibility of rapeseed cake is normally 76% (9 percentage units lower). If the poorer performance is to be explained from crude protein digestibility alone, the digestibility of crude protein in fermented rapeseed cake must be set lower than 76%.
- A combination of the above.

Besides rapeseed cake, the fermented product used in this trial also contained potato peel, molasses and wheat bran. The purpose of fermenting rapeseed cake is to improve the digestibility of protein and energy and possibly reduce glucosinolate content. Analyses demonstrated that the glucosinolate content of the fermented rapeseed was in fact reduced, but it is unclear whether this is attributed to fermentation, enzymatic degradation caused by myrosinase or damage by heat during drying post-fermentation (additional heat-treatment). Glucosinolate degradation products will have formed if glucosinolates were transformed via heat-treatment or myrosinase, but it is unclear whether the fermentation process also caused glucosinolates to transform into anti-nutritional substances.

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Background

Rapeseed cake is a by-product from rapeseed oil extraction. Rapeseed by-products are cheap alternatives to more expensive ingredients in weaner feed such as soybean meal, soybean concentrate and fishmeal. Today, it is possible to save DKK 2-10 (€ 0.3-1.3) per 100 kg weaner feed by using rapeseed by-products in the maximum recommended inclusion rates. Savings will increase as inclusion increases.

In 2009-2011, Pig Research Centre (PRC) completed two trials with rapeseed for weaners [1], [2]. Results revealed that weaners fed up to 15% rapeseed cake are able to grow efficiently and without adverse effect on health from weaning until 30 kg. Some of the rapeseed by-products used in these trials have had high content of intact glucosinolates, which has not affected weaner productivity significantly negatively despite increased weight of thyroid and liver in weaners and rats [2], [4].

Fermentation of rapeseed has been discussed for years and it is claimed that fermentation reduces glucosinolate content and improves digestibility of crude protein and phosphorus. It is furthermore claimed that fermentation improves fibre digestibility and results in a large concentration of lactic acid. It is therefore relevant to investigate whether fermentation of rapeseed may measurably reduce glucosinolate content and/or a measurably improve protein digestibility.

The aim of the trial was to investigate whether fermentation improves the quality of rapeseed as a feed ingredient in weaner feed (ie. improves nutrient digestibility and reduces glucosinolate content) measured primarily on productivity and secondarily on health.

Material and method

The trial was conducted in the weaner sections at Experimental Station Grønhøj. Pigs were moved to the weaner section at an average weight of 7.1 kg. All pigs were fed the same weaner diet. The first 14 days post-weaning, 2500 ppm zinc prescribed by the herd vet was administered to all pigs via the feed. When the pigs in a pen reached an average weight of approx. 9 kg, they switched to trial feed. Pig weight averaged 9.3 kg when they switched to trial feed. Pigs were weighed out of the trial when the average weight in the pen reached 30 kg or max. 6 weeks after transfer to the weaner section. Pig weight averaged 29.8 kg at departure from the weaner section. The trial comprised 44 replicates (pens) and approx. 560 pigs in each group. The diets for groups 2 and 3 contained the same percentage of rapeseed protein (see Appendix 2 for detailed information on the diets). The trial comprised three groups (trial design shown in Table 1).

Table 1. Trial design.

Group	1	2	3
Feed	Control	15% fermented rapeseed product incl. inoculation material	11% regular rapeseed cake

Feed

Diet compositions are shown in Appendix 2. The diets were pelleted and produced by Danish Agro. The feed for all three groups was produced on the same day to ensure that the same batch of ingredients was used in all three diets. Rapeseed cake used in groups 2 and 3 originated from the same batch of rapeseed from Scanola with glucosinolate content of 20.8 µmol/g. The batch was split into two, and one half was fermented by 'Fermentationsexperts A/S'. Both rapeseed products (regular and fermented) were subject to analyses before use and the current nutrient values used in the formulation of the diets (Appendix 1). According to 'Fermentationsexperts A/S', digestibility of fermented rapeseed is higher than that of traditional rapeseed. In the formulation of the diets, crude protein digestibility in traditional rapeseed cake was 76% and in fermented rapeseed cake 85%. The pigs were fed ad lib.

To be able to detect differences in digestibility of the fermented rapeseed products, the content of digestible crude protein of trial diets was below the standard in all three groups (digestible crude protein content of 133 g/FUgp and digestible lysine content of 9.0 g/FUgp).

Fermentation of rapeseed

Fermentation of rapeseed took place according to the below procedure:

1. The entire process is run batch-wise.
2. Approx. 5 tonnes
3. Rapeseed cake was mixed with bran, soy molasses, lactic acid bacteria and potato peel, water etc., in a cart for mixing cattle feed (see ratios in Table 2).
4. Once mixed, the product was stored separately, “stamped with a tractor”, and covered with plastic.
5. The trial batch was stored separately.
6. Storage time: 7 days. The batch was subsequently bagged in bigbags and forwarded for spin flash drying.

Table 2. Composition of fermented rapeseed product, %.

Ingredients	% in inoculation material	% in fermented rapeseed
Molasses	40.0	40.0
Water	26.7	
Potato peel, Danika	33.3	
Bran	-	10.0
Rapeseed cake	-	50.0
Dry matter	29.0	64.1

Glucosinolate content in both rapeseed products and in the feed was analysed at the University of Copenhagen, the Department of Basic Sciences and Environment, and content of bacteria and organic acids in both rapeseed products and the feed were analysed at the Department of Animal Science, Aarhus University (Nuria Canibe).

Recordings

Daily gain, feed consumption, treatments for disease and culled pigs were recorded. All recordings were made at pen level. Pigs were weighed when they switched to trial feed and at the end of the trial. Feed was weighed and recorded at each feeding at pen level using the computerised feeding system.

Production value

Production value (PV) was calculated for the entire trial period, and was based on an average of weaner prices of five years (September 2006 – September 2011):

- Price of a 7 kg pig: DKK 193 per pig, ± DKK 9.47 per kg
- Price of a 30 kg pig: DKK 331 per pig, ÷ DKK 5.72 per kg (25-30 kg) / + DKK 5.41 per kg (30-40 kg)
- Starter diet: DKK 3.06 per FUgp
- Weaner diet: DKK 1.77 per FUgp

Production value (PV) per place unit/day is based on: (value of gain - feed costs) / productive days.

Value of gain is based on: pig gain in kg × value of 1 kg gain. The feed prices used were identical in all groups.

Productive days: the number of days the average pig was in the trial.

Statistics

Production value was analysed with start weight as co-variate. The model included block and group as variables. Data was subject to analysis of normal distribution and prevalence of outliers and to analysis of variance in SAS under the PROC MIXED procedure. Two blocks were discarded due to recording errors. Significant differences are stated at 5 per cent level corrected for three comparisons in pairs (control and groups 2 and 3 with each other) with a bonferroni t-test. Health was analysed as secondary parameter in PROC GENMOD.

Results and discussion

Feed

The declared nutrient content and results of feed analyses are shown in Appendix 3. Results generally revealed good agreement between the declared and analysed nutrient content. However, the analyses found slightly less digestible crude protein than calculated in the formulation (group 1: 7%; group 2: 5%; and group 3: 5%), see Table 3.

Table 3. Calculated content of digestible crude protein and lysine.

	Expected	Analysed and calculated		
	Groups 1,2,3	Group 1 - Control	Gruppe 2 - Fermented rapeseed	Group 3 - Rapeseed cake
FUgp	110	111	110	111
Crude protein, g dig./FUgp	133	124	127	128
Lysine, g std. dig./FUgp	9.0	8.9	9.0	8.9

Rapeseed and rapeseed products

The rapeseed used for production of fermented rapeseed and rapeseed cake in group 3 had a glucosinolate content of 20.8 µmol/g (Table 4). Glucosinolate content was significantly lower in the fermented product than in the rapeseed cake. When converted to pure rapeseed dry matter, glucosinolate content was reduced by 50% in the fermented rapeseed and the content of 4-hydroxy-glucobrassicin was reduced to approx. one third of the original content in the rapeseed cake (Table 4). These differences between the two rapeseed products were retrieved in the analyses of the diets. The reduction in the total content of glucosinolate in the fermented rapeseed may be attributed to:

- Fermentation
- Heat degradation during drying
- Degradation via myrosinase

It is unclear whether degradation products formed following fermentation, but the degradation products forming after heat-treatment or degradation of myrosinase are harmful to pigs. Though rapeseed cake was subject to heat-treatment during oil extraction, some myrosinase activity may still remain. The addition of water and the increase in temperature following fermentation provide optimum conditions for enzymatic degradation of glucosinolates. The reduced 4-hydroxy-glucobrassicin content indicates that the product was damaged by heat during the drying process after fermentation.

Table 4. Glucosinolate content (µmol/g) in rapeseed products (5 samples) and feed (1 sample).*

	Group 2 - Fermented rapeseed (15% in feed)	Group 3 - Rapeseed cake (11% in feed)
Glucosinolate in ingredient	6.1	20.8
4-hydroxy-glucobrassicin in ingredient	0.6	2.9
Glucosinolate in pure rapeseed dry matter	9.8	23.5
4 –hydroxy-glucobrassicin in rapeseed dry matter	0.9	3.2
Glucosinolate in feed	0.7	1.7
4-hydroxy-glucobrassicin in feed	0.02	0.01

*Rapeseed products were analysed at two labs.

As a result of fermentation, the finished rapeseed product contained 5.6% lactic acid. The diet for group 2 contained 0.6% lactic acid.

Table 5. Organic acids (mmol/kg) and microbiological composition (LOG cfu/g) in fermented rapeseed.

	Group 2 - Fermented rapeseed	Group 3 – Rapeseed cake
Formic acid, %	0.02	0
Acetic acid, %	0.4	0
Propionic acid, %	-	0
Lactic acid, %	5.6	0
Ethanol, %	2.2	0.2
Enterobacteria, LOG cfu/g	$10^{<3}$	0
Lactic acid bacteria, LOG cfu/g	$10^{4.8}$	0
Yeast, LOG cfu/g	$10^{3.6}$	0
Fungus, LOG cfu/g	$10^{3.9}$	0
Clostridium perfringens, LOG cfu/g	$10^{3.2}$	0

Health

No differences were observed in mortality or treatments for diarrhoea between the groups. Mortality averaged 0.3%, and 3.6% of the pigs were moved to a hospital pen in the period after intermediate weighing. In this period, treatment frequency averaged 1.0 day per pig.

Productivity

The weight of the pigs in all three groups was identical at transfer to trial feed. Pigs fed fermented rapeseed had a significantly lower production value (-7%) compared with the control pigs and a lower production value (9%) than pigs fed regular rapeseed cake when using the same feed prices in the calculations. The reduced production value was attributed to a lower daily gain and a poorer FCR (Table 6). Analyses revealed no differences between control and the group fed rapeseed cake, which corresponds to results of other trials with rapeseed cake for weaners [1], [2].

Table 6. Production results and production value of weaners fed different types of rapeseed (9.3-29.8 kg).

Group	1	2	3
Feed	Control	Fermented rapeseed	Rapeseed cake
End weight, kg	29.1	28.9	29.4
Pigs	546	559	551
Blocks	43	44	43
Production results			
Feed intake, FUgp/day	1.04	1.02	1.03
Daily gain, g	531[a]	509[b]	533[a]
FCR, FUgp/kg	1.96[a]	2.00[b]	1.94[a]
Production value			
DKK per pig/day	1.32[a]	1.22[b]	1.35[a]
Index, identical feed price	100	93	102

a,b: Values with different superscripts are significantly different ($p<0.05$). The smallest difference in production value was 5 index points.

Lower productivity may be attributed to:

- The digestibility of protein in fermented rapeseed was estimated too high
- Formation of glucosinolate degradation products via myrosinase
- Heat-treatment, which may have led to
    a) Formation of glucosinolate degradation products
    b) Poorer digestibility of lysine as a consequence of heat-treatment

The main explanation for the reduced productivity is probably that the actual digestibility of crude protein and amino acids was lower than initially stated by the producer. Calculations show that the digestibility of rapeseed is probably lower than the value of rapeseed cake.

It is not possible to calculate the current production value as the price of fermented rapeseed cake was not provided. However, it was possible to calculate the price that can be paid for the feed for the three groups to obtain the same production value:

- Group 1 (control): DKK 2.00 per FUgp (€ 0.24 per kg)
- Group 2 (fermented rapeseed): DKK 1.89 per FUgp (€ 0.23 per kg)
- Group 3 (rapeseed cake): DKK 2.03 per FUgp (€ 0.25 per kg)

Consequently, the diet containing rapeseed cake must cost DKK 11 less per 100 FUgp (ie € 1.3 less per 100 kg) than the control diet to obtain the same production economy when calculated with five years' prices (September 2006 - September 2011).

Conclusion

The production value dropped significantly by 7% in the pigs fed fermented rapeseed compared with control and by 9% compared with the pigs fed rapeseed cake in the period approx. 9-30 kg. For a pig producer to obtain the same production value, a diet containing 15% fermented rapeseed must cost DKK 11 less per 100 FUgp (ie € 1.3 less per 100 kg). The most likely explanation of the loss in productivity is that the protein digestibility of the fermented rapeseed cake used in the formulation was set too high and that glucosinolate degradation products formed. There were no differences in production value between pigs given control feed and regular rapeseed cake.

References

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[2] Maribo, H. (2012): Rapeseed cake for weaners – variety and processing. Trial report no. 949, Pig Research Centre.

[3] Schone, F., F. Tischendorf, M. Leitrer, H. Hartung,& I Bargholz (2001) Effects of Rapeseedpress cake glucosinolates and iodine on the performance, the thyroidgland and the liver vitamin A status in pigs. Archives of Anim. Nutr. Vol 55:4, pp333-350

[4] 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.

Appendix 1

Analysis of nutrient content and glucosinolates in the rapeseed products used in this trial (average of 8 analyses)

Ingredient	Unit		Fermented rapeseed		Rapeseed cake	
FUgp	Per 100 kg		93.7		92.7	
Crude protein	% of product		28.7		29.4	
Fat	% of product		10.4		11.2	
Ash	% of product		6.2		6.2	
Water	% of product		8.8		12.2	
Fibre	% of product		11.7		11.5	
EDOM[1]			77.8		79.9	
EDOMi [2]			60.8		60.6	
Calcium	g/kg		6.04		6.38	
Phosphorus	g/kg		10.95		8.61	
Lysine	% of crude protein	g/kg	5.00	14.35	5.37	15.79
Methionine	% of crude protein	g/kg	1.69	4.85	1.78	5.23
Cystine	% of crude protein	g/kg	1.97	5.65	2.16	6.35
Threonine	% of crude protein	g/kg	3.90	11.19	4.09	12.02
Tryptophan	% of crude protein	g/kg	1.12	3.21	1.27	3.73
Isoleucine	% of crude protein	g/kg	3.37	9.67	3.90	11.47
Leucine	% of crude protein	g/kg	6.15	17.65	7.10	20.87
Histidine	% of crude protein	g/kg	2.43	6.97	2.79	8.20
Phenylalanine	% of crude protein	g/kg	3.50	10.05	4.00	11.76
Tyrosine	% of crude protein	g/kg	2.63	7.55	3.02	8.88
Valine	% of crude protein	g/kg	4.52	12.97	5.19	15.26

[1] EDOM = Enzyme Digestible Organic Matter

[2] EDOMi = Enzyme Digestible Organic Matter, ileum

Appendix 2

Composition of diets (%)

Group	1	2	3
Wheat	58.8	50.2	49.5
Barley	15.0	15.0	15.0
Rapeseed cake	-	-	10.7
Fermented rapeseed	-	15.0	-
Soybean meal, dehulled	15.9	9.5	12.0
Potato protein	2.0	2.0	2.0
Wheat bran	-	-	2.1
Molasses, sugar beet	1.0	1.0	1.0
Salt	0.4	0.4	0.4
Feed lime	1.6	1.6	1.6
Monocalcium phosphate	1.3	1.0	1.1
Ronozyme NP	0.015	0.015	0.015
Lysine	0.38	0.36	0.34
Threonine	0.09	0.07	0.06
Methionine	0.10	0.07	0.08
Tryptophan	0.03	0.04	0.03
Benzoic acid	1.0	1.0	1.0
Vitamin pre-mix	0.4	0.4	0.4
Microgrits (coloured particles)	0.05	0.05	-

Appendix 3

Analysed nutrient content (average of ten analyses)

Group	1		2		3	
	Control		Fermented rapeseed		Rapeseed cake	
	Guarantee	Analysis	Guarantee	Analysis	Guarantee	Analysis
FUgp/100 kg	110.0	111.0	110.0	110.3	110.0	110.7
Crude protein, %	17.6	16.0	17.4	16.5	17.7	16.8
Fat, %	3.4	3.8	5.2	5.6	5.3	6.0
Water, %	13.4	14.1	12.7	14.2	13.1	14.4
Calcium, g/kg	9.7	8.5	9.7	9.3	9.7	8.9
Phosphorus, g/kg	6.2	5.8	6.5	6.1	6.4	6.1
Lysine, g/kg	11.1	11.0	11.2	11.1	11.4	11.3
Methionine, g/kg	3.5	3.3	3.5	3.3	3.6	3.3
Cystine, g/kg	3.0	2.9	3.3	3.1	3.4	3.2
Methionine+cystine, g/kg	6.5	6.2	6.8	6.4	7.0	6.5
Threonine, g/kg	6.9	6.7	7.1	6.9	7.2	7.0
Isoleucine, g/kg	6.7	6.3	6.7	6.3	6.9	6.5
Leucine, g/kg	12.4	11.6	12.5	11.7	12.7	12.2
Histidine, g/kg	4.0	3.8	4.2	3.8	4.2	4.0
Phenylalanine, g/kg	7.4	7.6	7.4	7.4	7.6	7.8
Tyrosine, g/kg	5.8	5.6	5.8	5.9	5.9	5.6
Phenylalanine + tyrosine, g/kg	13.2	13.2	13.2	13.3	13.5	13.4
Valine, g/kg	7.9	7.4	8.3	7.7	8.4	8.0
Aspartic acid, g/kg	-	14.4	-	13.6	-	14.5
Serine, g/kg	-	7.8	-	7.7	-	8.0
Glutamic acid, g/kg	-	32.6	-	31.4	-	32.4
Proline, g/kg	-	10.9	-	11.3	-	11.2
Glycine, g/kg	-	6.8	-	7.3	-	7.4
Alanine, g/kg	-	6.6	-	7.0	-	7.1
Arginine g/kg	-	9.5	-	9.4	-	9.9
Phytase	1500	1649	1500	1738	1500	1961

Digestible protein and amino acids calculated on the basis of analysed content

Group	1	2	3
Crude protein	124	127	128
Lysine	8.85	8.97	8.89
Methionine	2.69	2.73	2.72
Met+Cys	4.87	5.09	5.06
Threonine	5.29	5.39	5.34
Tryptophan	2.52	1.98	1.97
Isoleucine	4.86	4.84	4.94
Leucine	9.01	9.11	9.24
Histidine	2.95	3.01	3.08
Phenylalanine	5.98	5.88	6.02
Phen+tyrosine	10.33	10.39	10.27
Valine	5.65	5.84	5.92