Processing of rapeseed and meal to reduce the content of Sinapine and Glucosinolates

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INTRODUCTION

The use of rapeseed and meal in commercial diets for layers is limited because of its sinapine content which causes a fishy taint in eggs from susceptible hens ("tainters") which are usually brown-egg-layers. Sinapine, the choline ester of sinapic acid, is present in rapeseed at levels from 0.6 to 1.8 %. The microbes of the large intestine hydrolyze sinapine to choline and sinapic acid. The microbes further transform choline to trimethylamine (TMA) which is finally converted to trimethylamine oxide. The presence of excessive levels of TMA in eggs, resulting from the impaired ability by "tainters" to metabolize TMA, causes the fishy odour (Hobbson-Frohock et al. 1975, 1977; Griffiths et al. 1979, 1980; March and MacMillan 1979, 1980; Butler and Fenwick 1984).

Brown-egg layers constitute a high percentage of egg-laying stock in many countries. Since it is not practical to formulate diets with and without rapeseed or meal for white- and brown-egg-layers, respectively, it is of interest to eliminate or at least lower the content of sinapine.

As is well known sinapine is hydrolyzed under alkaline conditions. The objective of the present study was to achieve hydrolysis under different processing conditions (water, heat, pressure and time) and with different levels of addition of Na_2CO_3. Hydrolysis of sinapine ensures that the free choline is absorbed in the small intestine and does not reach the large intestine. In addition, the differently processed samples of rapeseed (00-variety) and meal were analyzed for any remaining glucosinolate levels. Glucosinolates are known as anti-nutritive factors in rapeseed and meal. They reduce feed intake and increase the size of the thyroid gland, the extent to which is dependent on the level of glucosinolates in the diet.

MATERIALS AND METHODS

The processing conditions (at differing pH, temperature, pressure and time) to achieve optimum hydrolysis of sinapine in rapeseed and meal were first developed under laboratory conditions. Different samples of commercial rapeseed or meal of the 00-variety were used in these experiments. In contrast to other experiments (Skrivastava and Hill 1976; Fenwick et al. 1979; Goh 1982) it was not only our objective to minimize the sinapine content but to achieve this at the smallest expense.

The results were further evaluated under practical conditions in a factory for feedmill equipment (Kahl Nachf., Hamburg). In addition to sinapine, glucosinolates were analysed also by High-Performance Liquid Chromatography. These analyses were carried out by Kallweit, LUFA-Kiel.

In experiments with laying hens, as tainters selected, diets including processed and unprocessed rapeseed meal, respectively, in comparision to a control diet without 00-rapeseed

meal were fed. Egg yolk was analysed for TMA and the level of fishy odour was evaluated.

The growth experiments with chickens started following a selection period of 13 to 16 days to select chickens with minimal variation in BW. The chickens were kept in single cages in a climate-controlled room 4 to 5 weeks. Six groups each containing 12 chickens were alloted to different dietary treatments. Feed consumption and BW were recorded. The results were statistically analyzed.

RESULTS AND DISCUSSION

In the first experiments Na_2CO_3 was found to be the best supplement to obtain an optimum pH to hydrolyse sinapine with a minimum supply of water. For the reaction in the incubator dry matter content of only 80 % in the meal was necessary. A temperature of 90° C during processing gave the best results in all experiments. The results for reducing the contents of sinapine, glucosinolates and goitrin, by variations in the level of Na_2CO_3, reaction time and pressure in both under labaratory and practical conditions, are presented in Table 1. A minimum of 4 % Na_2CO_3 is necessary for a complete reduction of sinapine content. Only a pressure of 30 bar and an incubation time of 45 min resulted in a complete reduction of the remaining glucosinolates and their metabolites as for example goitrine.

The reduction in the content of sinapine in rapeseed meal included at a level of 12 % in the layer diets, resulted in a very low content of trimethylamine in the egg yolk and the absence of fishy taint in eggs of the selected hens ("tainters"). However, as shown in Table 2, in two of the three experimental groups the feed intake was slightly reduced. The addition of Na_2CO_3 during processing of rapeseed meal reduced feed intake, as can be derived from the growth trial with broilers (Table 3), while no Na_2CO_3 supplementation is as good for performance as no rapeseed meal in the diet (experiment 2). There was no explanation for the reduced feed intake in the control diet in experiment 1.

CONCLUSIONS

Sinapine is an anti-nutritive factor in rapeseed or rapeseed products that causes a fishy taint (trimethylamine) in eggs, esp. of brown-egg layers. Glucosinolates are known as antinutritive factors that reduce the feed intake and that increase the size of the thyroid gland, dependent on the level of glucosinolates in the diet. Different processing conditions were applied (pH, temperature, pressure, time) to reduce the anti-nutritional effect of these factors. Processing of rapeseed under standardized conditions (4 % Na_2CO_3, pressure of 30 bar and for a time of 45 min) resulted in a complete reduction in the content of sinapine and of glucosinolates which, in turn, resulted in an significant reduction of fishy taint in eggs of selected laying hens ("tainters"). Three growth experiments, each with 72 broilers kept in single cages, were used to evaluate the effect of the aforementioned processing conditions on performance. The growth performance was best under processing conditions described above but without any Na_2CO_3 supplementation.

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Table 1. The effect of different processing conditions on the sinapine, glucosinolate and goitrin content in rapeseed and meal.
(Heat 90°C; Moisture 20 %)

Time, min.	Na_2CO_3, g/kg	Pressure, bar	Sinapine, mg/kg	Gluco-sinolate, µmol/g	Goitrin, mg/kg
Laboratory experiments:					
Rapeseed meal I untreated			4 500	16.8	1 280
45	0	----	4 200	5.6	423
45	20	----	1 840	1.4	119
45	40	----	161	< 1	77
Rapeseed meal II untreated			6 120	3.2	350
45	20	----	1 941	< 1	< 50
45	30	----	889	< 1	< 50
60	20	----	1 839	< 1	< 50
60	30	----	762	< 1	< 50
75	20	----	1 932	< 1	< 50
75	30	----	540	< 1	< 50
Rapeseed I untreated			4 700	18.9	847
45	20	----	260	9.3	283
45	30	----	410	2.1	122
45	40	----	80	4.7	283
Practical experiments					
Rapeseed meal III untreated			8 820	21.3	779
45	0	30	7 190	4.7	222
70	15	65	3 480	< 1	< 50
45	30	30	661	4.6	178
70	30	65	416	< 1	< 50
45	35	30	176	5.8	152
70	35	65	50	< 1	< 50
45	40	30	187	2.6	53
Rapeseed II untreated			4 500	14.5	803
45	40		< 40	3.1	< 50

Table 2. Composition of the experimental diets, feed intake, egg production and trimethylamine (TMA) content in eggs.

Composition (% DM) of the diets:

	control	untreated-rapeseed meal	treated-rapeseed meal
Wheat	34	35	35
Corn	16.2	21	21
Soybean meal	25	14.4	14.4
Rapeseed meal	-	12	12
Oat hulls	14	7	7
Rapeseed oil	1.5	1.5	1.5
Premix	9.3	9.1	9.1
Crude protein	19.0	17.9	17.9
Crude fat	4.2	4.3	3.7
Crude fiber	8.7	6.4	6.6
Ash	11.7	11.6	12.2
Na	0.3	0.3	0.5
Sinapine	-	0.45	0.01

	$\bar{x}$	(CV)	$\bar{x}$	(CV)	$\bar{x}$	(CV)
g DM intake/hen/period[1]:						
Group 1[2]	1742[a]	(13)	1703[a]	(8)	1540[b]	(9)
Group 2	1625	(8)	1688	(16)	1686	(14)
Group 3	1717[a]	(12)	1780[a]	(18)	1624[b]	(20)
Number of eggs/hen/period:						
Group 1	13	(10)	12	(14)	12	(11)
Group 2	13	(13)	13	(11)	13	(8)
Group 3	12	(13)	13	(12)	13	(12)
µg/10g yolk TMA:						
Group 1	15	(51)	69	(20)	5	(57)
Group 2	7	(31)	58	(56)	8	(40)
Group 3	1	(63)	53	(59)	11	(26)

[1] Period = 15 days
[2] Hens per group = 8
[a,b] Values within the same row followed by different letters differ ($p<0.5$)

Table 3. The influence of differently processed rapeseed meal in diets for broilers on growth performance.

Diet Nr.:	I	II	III	IV	V	VI
Composition (%) of broiler diets:						
Corn	52	49	49	49	49	49
Soybean meal	40	31	31	31	31	31
Rapeseed meal	-	12	12	12	12	12
Rapeseed oil	4	4	4	4	4	4
Premix	4	4	4	4	4	4
Treatments of rapeseed meal in the diets:						
Na_2CO_3, g/kg		0	35	0	35	15
Pressure, bar		0	30	30	65	65
Time, min		0	0	45	45	70
Glucosinolates (GLS) and Sodium (Na) content in treated rapeseed meal:						
GLS, µmol/g		21.3	5.8	4.7	< 1	< 1
Goitrin, mg/kg		779	152	222	< 50	< 50
Na, % DM		0.03	2.17	0.03	2.13	0.69
Chemical composition (% DM) of the diets:						
Crude protein	24.6	24.7	23.9	23.9	23.4	24.2
Crude fat	8.2	8.4	8.4	8.0	8.3	8.2
Ash	7	7.7	7.4	7.6	7.1	6.9
Sodium	0.17	0.16	0.26	0.16	0.26	0.13
GLS, µmol/kg	-	2299	615	506	106	108
Broiler performance:						
Number of animals:						
experiment 1	11	10	11	11	11	11
experiment 2	11	10	10	12	11	
DM intake, g:						
experiment 1	1870	1923	1684	1810	1794	1780
experiment 2	2100	1864	1854	2106	1856	
Total intake of Glucosinolates, µmol:						
experiment 1	-	4421	1036	916	190	192
experiment 2	-	4285	1140	1066	197	
body weight gain, g:						
experiment 1	1195[a]	1194[a]	968[b]	1182[a]	1068[bc]	1094[ac]
experiment 2	1322[a]	1150[b]	1045[bc]	1257[a]	1070[bc]	

[a,b] Values within the same row followed by different letters differ ($p<0.5$)