Annales Agriculturae Fenniae

Maatalouden tutkimuskeskuksen aikakauskirja

Journal of the Agricultural Research Centre

Vol. 22, 4

Annales Agriculturae Fenniae

JULKAISIJA — PUBLISHER

Maatalouden tutkimuskeskus
Agricultural Research Centre

Ilmestyy 4—6 numeroa vuodessa
Issued as 4—6 numbers a year

ISSN 0570-1538

ALASARJAT — SECTIONS

Agrogeologia et -chimica — Maa ja lannoitus ISSN 0358-139X
Agricultura — Peltoviljely ISSN 0358-1403
Horticultura — Puutarhaviljely ISSN 0358-1411
Phytopathologia — Kasvitaudit ISSN 0358-142X
Animalia nocentia — Tuhoeläimet ISSN 0517-8436
Animalia domestica — Kotieläimet ISSN 0358-1438

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Maatalouden tutkimuskeskus, Kirjasto, 31600 Jokioinen

DISTRIBUTION AND EXCHANGE

Agricultural Research Centre, Library, SF-31600 Jokioinen

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ANNALES AGRICULTURAE FENNIAE, VOL. 22. 195–205 (1983)

Seria ANIMALIA DOMESTICA N. 63 – Sarja KOTIELÄIMET n:o 63

USE OF TOWER RAPESEED MEAL SEPARATELY AND TOGETHER WITH PEA MEAL TO REPLACE FISH AND SOYBEAN MEAL IN LAYERS' DIET AT VARYING PROTEIN CONCENTRATIONS

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KIISKINEN, T. 1983. **Use of Tower rapeseed meal separately and together with pea meal to replace fish and soybean meal in layers' diet at varying protein concentrations.** Ann. Agric. Fenn. 22: 195–205. (Agric. Res. Centre, Inst. Anim. Husb., 31600 Jokioinen, Finland.)

Rapeseed meal (RSM) from the low-glucosinolate cultivar Tower was fed in two experiments as a replacement for fish and soybean meal at three protein levels (calc. 13,5, 14,8, 16,2 %) of layers' diet. In the first experiment the RSM formed c. 50 % of the supplementary protein (5, 8 and 11 % in diet) and in the second experiment both RSM and pea meal (PM) were included at levels of 4, 8 and 12 %, replacing all fish and soybean meal.

No significant differences in egg production, egg weight or mortality could be ascertained between the supplementary protein groups and protein levels in each experiment. Because the diets were not isocaloric, feed consumption by the RSM-PM groups was significantly higher ($P < 0{,}01$) than that by the control groups and the feed efficiency of the test protein groups was inferior (though not significantly) to the control groups in each experiment. The final body weight of the hens in the RSM-PM groups was significantly ($P < 0{,}001$) lower than that of the control groups. Tower RSM caused an average thyroid enlargement of 30 and 60 % ($P < 0{,}001$) in Experiments 1 and 2, respectively.

Index words: rapeseed meal, pea meal, protein level, laying hen, egg production, mortality, thyroid weight.

INTRODUCTION

Increased mortality, and reduced egg production and efficiency of feed conversion of laying birds have often been reported when more than 5 % rapeseed meal (RSM) from the older varieties has been included in the diets (VOGT et al. 1969 SUMMERS et al. 1971, MARCH et al. 1972, LESLIE and SUMMERS 1972, OLOMU et al. 1975, THOMAS et al. 1978, LIPINSKA 1978). The adverse effects have been attributed to the erucic acid, glucosinolates and low energy content of such meals. Plant breeding has developed new varieties (low erucic acid, low glucosinolate, low fibre) for commercial production. Meals derived from low-erucic acid and low-glucosinolate cultivars (LG-RSM) do not have any drastic effects on egg production compared with soybean meal (SBM), even when used up to 10–15 % in diets (VOGT and TORGES 1976, SLINGER et al. 1978, ROBBLEE et al. 1978, THOMAS et al. 1978, HULAN and PROUDFOOT 1980, 1981). However, mortality has often increased, and egg weight and feed efficiency decreased with fairly high contents of LG-RSM. A typical phenomenon, which is also associated with the use of LG-RSM, is the increase in size of the thyroid gland. The goitrogenic effects are due to glucosinolates, or primarily to their breakdown products – chiefly goitrin.

Moderate amounts of up to 30 % pea meal (PM) in layers' diets do not cause any problems to egg production (MORAN et al. 1968, ANDERSSON and ELWINGER 1976, GUILLAUME 1978, RICHTER 1981). Because the first limiting amino acid in PM as well in RSM is methionine, this amino acid ought to be supplemented in the rations if these sources of protein are used to any significant extent.

The potential for producing plant protein available to single stomach animals is limited under Finnish conditions. If the situation arises in which Finland must become self-sufficient in its protein resources, unnecessary use of protein will have to be avoided. This study was designed to compare the performance of laying hens feeding on three different protein levels, using LG-RSM separately or together with PM as the main supplementary protein in the diets.

MATERIAL AND METHODS

Animals and housing

White Leghorn pullets (strain SK 12) were transferred at 20 weeks of age to two-tier stair-step model laying cages. Three hens were placed at random in one cage (400 cm^2/hen.). The hens were fed a commercial laying ration until 24 weeks of age when they were placed on the experimental diets. At this point their average egg laying intensity was 74 % in Experiment 1 and 76 % in Experiment 2. The duration of the first experiment was 9 periods of 28 days and that of the second experiment 10 × 28 days. In the windowless building 11 hours of light per day was provided at the start of the experiments and then increased gradually to a maximum of 16 hours. The lighting intensity was 10 lux. The room temperature varied in winter between 15 °C and 20 °C, and in spring and summer between 15 °C and 25 °C. The variations in relative humidity were 45—65 % and 40—90 %, respectively.

Experimental design

Each experiment had a 2 × 3 factorial design. The factors in Experiment 1 were the rapeseed meal level and the protein concentration. The RSM levels were 0 and 50 % of the supplementary protein and the calculated protein contents were 13,5, 14,8 and 16,2 %. In the second experiment the calculated protein concentrations were the same as in the first experiment, but RSM and PM together replaced all fish and soybean meal in the diets. In both trials, four replicate groups of 30 hens were used for each treatment. Thus the levels of protein sources had 12 replicates and the protein contents 8 replicates each.

Diets and feeding

The rapeseed meal was extracted from the low-glucosinolate Tower variety *(Brassica napus)*. The pea meal was a mixture of different cultivars. The concentration of RSM depended on the protein level: 5, 8 and 11 % in Experiment 1 and 4, 8 and 12 % in Experiment 2 (Tables 1 and 2). The contents of PM were the same as those of RSM (Expt. 2). Analyses of each test protein source are presented in Table 3.

Meat and bone meal and single cell protein were included in all diets as domestic protein sources. An attempt was made to make the ME concentration of the diets the same with supplementary fat. Synthetic DL-methionine was added to produce the same concentration of this amino acid in each of the diets. The experimental diets were in meal form and feeding was ad libitum.

Measurements

The numbers and total weight of eggs were measured daily, and the feed consumption was measured at four periods for each replicate of the treatments. The hens were weighed individually at the beginning and at the end of the experiments. Mortality was recorded.

A single day's production was taken three times during the experiments for determinations of egg quality. The weight of albumen and Haugh unit (HU) were determined with Ames HU micrometer and the specific weight of the eggs using NaCl solutions. Possible deterioration in flavour due to the RSM feeding was investigated by tasting eggs from layers on the two highest RSM levels and the corresponding controls. The total number of people who participated in these tests was 16.

The number of thyroid glands removed and weighed at the end of the experiments was 12 and 17 for each RSM concentration in Experiments 1 and 2, respectively.

Analyses of diets and blood

A proximate analysis (Weende) was done for each test protein and each lot of the feed mixtures. Twisselman ether extraction was used in determination of the crude fat. Amino acid analysis was performed on protein feeds and on a common sample of each diet. Before elution with a gas chromatograph (Hewlett Packard 5710) the samples were hydrolysed in 6N HCl saturated with nitrogen gas (110 °C for 20 hours). Calcium and phosphorus determinations were performed in the laboratory of Viljavuuspalvelu Oy. The contents of glucosinolates in RSM and tannins in RSM and PM were determined in the State Institute of Agricultural Chemistry. Glucosinolates were analysed by gaschromatography (Thies 1976) and tannins by the FOLINDENIS method (Herrmann 1963).

At the end of the first experiment, blood samples were taken from the right wing vein of nine hens per treatment. Haemoglobin was determined as cyanomethaemoglobin and haematocrit by centrifuging (5 minutes, 1500 rpm). Serum analyses (total protein, albumin and serum protein-bound iodine) were performed in a private laboratory (Yhtyneet Kliiniset Laboratoriot Oy).

Statistical analyses

Mean values of egg production, feed consumption and mortality obtained for replicates and data of body weights, egg quality, blood values and thyroid weights were subjected to analyses of variance. The significance of differences between treatments, levels of protein sources and protein concentrations was assessed by Tukey's test (Steel and Torrie 1960) and by the t-test.

RESULTS AND DISCUSSION

The analysed protein contents of the diets corresponded well with the calculated values, exceeding them slightly (Tables 1 and 2). The methionine contents of the diets and especially that of PM (Table 3) were, however, lower than the calculated or table values, referring to possible destruction of this amino acid by hydrolysis. The determined lysine content of some diets also deviated markedly from the calculated value.

The content of progoitrin was approximately the same and that of gluconapin lower than the values which Olsen and Sørensen (1980) reported for TOWER rapeseed. The content of tannins (0,5 %) was equal to the values which Aulin (1979) determined for peas from food cultivars.

The inclusion of Tower RSM separately or together with PM in the diets did not significantly affect egg production (Table 4). The successful use of LG-RSM up to 11–12 % in the diet agreed with the results of several earlier studies with 10–15 % RSM of Tower or other LG cultivars in layers' diets (Vogt and Torges 1976, Slinger et al. 1978, Thomas et al. 1978, Robblee et al. 1978, Hulan and Proudfoot 1980, 1981). Because the number of replicates was only four, the relatively small differences between the treatments could not be statistically confirmed.

No significant interaction could be ascertained be-

Table 1. Percentage composition, calculated and analysed contents of the diets in Expt. 1.

Diet	1	2	3	4	5	6
Fish meal	1	–	2	1	3	1,5
Soybean meal	2	–	4	–	6	2
RSM (Tower)	–	5	–	8	–	11
Meat and bone meal	4	→	→	→	→	→
Single cell protein[1)]	1	→	→	→	→	→
Barley	57	55	55	52	53	49
Oats	23,5	23	22,5	22	21,5	19,2
Grass meal	4	→	→	→	→	→
Soya oil	0,5	→	→	→	→	→
Animal fat	–	0,5	–	0,5	–	0,8
Limestone flour	6	→	→	→	→	→
Sodium chloride	0,5	→	→	→	→	→
Mineral premix[2)]	0,25	→	→	→	→	→
Vitamin premix[3)]	0,15	→	→	→	→	→
DL-methionine	0,08	→	→	→	→	→
Crude prot. % calc.	13,5	13,5	14,8	14,8	16,2	16,2
" " anal.	14,1	14,0	15,3	15,1	16,4	16,7
ME MJ/kg calc.	10,20	10,15	10,20	10,06	10,20	10,00
Methionine % calc.	0,30	0,30	0,31	0,31	0,32	0,32
" anal.	0,28	0,28	0,30	0,29	0,30	0,30
Lysine % calc.	0,59	0,56	0,69	0,65	0,79	0,77
" anal.	0,47	0,41	0,69	0,63	0,90	0,73
Calcium % anal.	2,83	3,08	2,55	3,23	2,97	3,16
Phosphorus " "	0,65	0,61	0,62	0,61	0,62	0,69

1) The domestic SCP products Pekilo and Silva

2) Supplied per kg of diet: 20 mg Fe, 45 mg Zn, 48 mg Mn, 4 mg Cu, 0,6 mg Co, 0,5 mg I, 0,1 mg Se.

3) Supplied per kg of diet: 15000 IU vitamin A, 1800 IU vitamin D_3, 20 mg vitamin E, 1 mg vitamin K, 3,5 mg B_2, 1 mg B_6, 15 mg B_{12}, 18 mg niacin, 0,24 mg folic acic, 500 mg choline chloride.

Table 2. Percentage composition, calculated and analysed contents of the diets in Expt.2.

Diet	1	2	3	4	5	6
Fish meal	1	–	2	–	3	–
Soybean meal	3	–	5	–	7	–
RSM (Tower)	–	4	–	8	–	12
Pea meal	–	4	–	8	–	12
Meat and bone meal	3	→	→	→	→	→
Single cell protein	1	→	→	→	→	→
Barley	58	55	55,5	50	54	45
Oats	23	22	22,5	18,5	21	15,5
Grass meal	3	→	→	→	→	→
Soya oil	0,5	→	→	→	→	→
Animal fat	–	0,2	–	0,35	–	0,5
Limestone flour	6	→	→	→	→	→
Dicalcium phosphate	0,5	→	→	→	→	→
Sodium chloride	0,5	→	→	→	→	→
Mineral premix[1)]	0,25	→	→	→	→	→
Vitamin premix[1)]	0,15	→	→	→	→	→
DL-methionine	0,08	→	→	→	→	→
Crude prot. % calc.	13,5	13,5	14,8	14,8	16,2	16,2
" " anal.	13,8	13,5	15,1	15,0	16,2	16,4
ME MJ/kg calc.	10,25	10,17	10,25	10,00	10,25	9,89
Methionine % calc.	0,30	0,30	0,31	0,30	0,32	0,30
" " anal.	0,24	0,24	0,29	0,27	0,28	0,25
Lysine % calc.	0,60	0,57	0,70	0,67	0,79	0,77
" " anal.	0,51	0,54	0,68	0,63	0,65	0,74
Calcium " anal.	3,08	3,23	3,16	2,95	3,10	2,86
Phosphorus " "	0,61	0,61	0,69	0,63	0,67	0,73

1) Supplies as in Expt. 1.

Table 3. Analysis of Tower rapeseed meal and pea meal

	Tower RSM	Pea meal
Proximate analysis (± SD)		
N	5	4
Dry matter %	87,3 ± 0,3	84,4 ± 1,0
% in DM.		
Crude protein	40,5 ± 0,4	27,5 ± 1,4
Crude fat	1,7 ± 0,4	1,2 ± 0,2
" fibre	12,9 ± 0,3	6,2 ± 0,7
Ash	8,2 ± 0,2	3,4 ± 0,1
Special analysis (N 1)		
Tannins	0,9	0,5
Gluconapin % in fat free DM.	0,44	–
Glucobrassicanap. "	0,03	–
Progoitrin	0,55	–
2-OH-4 pentenylgluc.	0,14	–
Amino acids (g/16gN)		
Methionine	1,4	0,4
Cystine	1,5	0,8
Lysine	6,0	5,8
Arginine	5,7	7,9
Histidine	2,8	2,1
Leucine	6,9	6,2
Isoleucine	3,3	3,6
Phenylalanine	4,0	4,1
Tyrosine	3,2	3,4
Threonine	3,9	3,1
Valine	4,6	4,2
Glycine	5,0	3,7
Alanine	4,5	4,0
Asp. acid	6,5	9,5
Glutam. acid.	16,7	14,8
Serine	4,0	2,4
Proline	6,0	3,9

Table 4. Egg production in Experiments 1 and 2.

	Protein level % Expt. 1./Expt. 2. 14,0/13,6	15,2/15,0	16,5/16,3	$\overline{X}$	SE[1]
Expt. 1.					
RSM	Egg production %				
0	66,2	69,3	67,8	67,8	0,99
+	64,9	66,9	67,4	66,4	1,05
$\overline{X}$	65,6	68,1	67,6	67,1	0,72
SE	1,21	1,26	1,27	–	
	Egg weight g				
0	60,1	59,8	59,9	59,9	0,27
+	59,2	59,6	60,2	59,7	0,27
$\overline{X}$	59,7	59,7	60,0	59,8	0,19
SE	0,35	0,34	0,32	–	
	Production g/hen/day				
0	39,6	41,2	40,4	40,4	0,44
+	38,2	39,6	40,3	39,4	0,49
$\overline{X}$	38,9	40,4	40,3	39,9	0,33
SE	0,55	0,57	0,59	–	
Expt. 2.					
RSM+PM	Egg production %				
0	70,0	67,6	68,9	68,8	0,95
+	68,1	68,6	69,1	68,6	0.95
$\overline{X}$	69,0	68,1	69,0	68,7	0,67
SE	1,15	1,35	1,09	–	
	Egg weight g				
0	60,1	60,3	60,4	60,2	0,28
+	59;7	59,5	60,1	59,8	0,28
$\overline{X}$	59,9	59,9	60,2	60,0	0,20
SE	0,34	0,34	0,34	–	
	Production g/hen/day				
0	41,7	40,5	41,4	41,2	0,42
+	40,4	40,5	41,3	40,7	0,43
$\overline{X}$	41,1	40,5	41,3	41,0	0,30
SE	0,51	0,56	0,48	–	

[1] Standard error of mean.

tween the use of RSM and protein level with regard to the production performance (Table 6). However, in the case of the lowest protein level in Experiment 1 the difference between the two RSM levels in laying percentage and egg weight may be attributed to the differences in protein quality of the diets. The contents of lysine and isoleucine in rapeseed protein are lower than in soybean and fish protein. According to Muztar et al. (1980) true amino acid availability values are lower for LG-RSM than SBM, ranging from 82 to 95 % and 90 to 97 %, respectively.

There was a tendency towards decreased egg weight when RSM and PM were used together, replacing all fish and soybean meal (Expt. 2). One possible but not very probable reason for this is the haemagglutinins in peas, but relatively high contents of PM are needed to decrease egg weight by any notable amount (Guillaume 1977, Olaboro et. al. 1980, Davidson 1980).

Neither protein level had any significant effect on the performance of hens in any trial, although in Experiment 1 the lowest level (14 %) caused an approximately 2 percentage units lower egg production than the higher protein levels (Table 4). Apparently the quality of supplementary protein was poor because a great deal of it was composed of meat and bone meal. The low analysed values of lysine for the low protein diets refers at least to the deficiency of this amino acid, but the decrease in production was surprisingly slight if we compare the low contents of lysine in the diet (0,41/0,47 %) to the requirement 0,52 % (NRC 1977) at this energy level. The insignificant effect of the protein level (13,6–16,5 %) in this study is not uncommon, because other authors have not found any adverse effects on egg production by decreasing the protein content to 12–13 % in the diet (Miller et al.

1957, THORNTON et al. 1957, FERNANDEZ et al. 1973, KOLSTAD and LIEN 1974, EL BOUSHY and MUILWIJK 1978).

Feed intake by the test protein groups was higher (P < 0,05) than that of the control groups in Experiment 2, but in Experiment 1 the difference between the control and RSM groups was small. This is in agreement with the calculated ME contents of the diets.

Although attempts were made to balance the ME contents of the diets, differences still remained and were greater in Experiment 2 than in Experiment 1 (Tables 1 and 2). The protein consumption of the RSM-PM groups was higher (P < 0,01) than that of the control groups. Naturally, an increase in the protein content produced an increase in the protein consumption (P < 0,01). There was interaction between source and level of protein in feed and protein intake (Table 6). This can be explained by the differences in the ME contents between the control and test protein groups. This difference increased when the protein level rose.

In each trial the test protein groups consumed an average of 0,1 kg more feed per kg eggs than the control groups (Table 5). There was a tendency towards decreased feed efficiency when the protein content increased in Experiment 1. The consumption of protein per kg eggs increased (P < 0,01) when the protein concentration increased.

Body weight increased in all groups (Table 7). In Experiment 1 the increase was approximately to the same extent in all treatments but in Experiment 2 the final body weight and percentage gain of the RSM-PM groups were significantly (P < 0,001) lower than those of the control groups.

Mortality was not significantly affected by the inclusion of RSM in layers' diets, but in both trials mortality was, however, higher in the test protein groups (Table 7). Furthermore, the LG meals in concentrations exceeding 10 % of the diet have shown a tendency to increase mortality (GRANDHI et al. 1977, SLINGER et al. 1978, THOMAS et al. 1978, HULAN and PROUDFOOT 1980, 1981).

The differences in the egg quality parameters between the dietary treatments were generally slight (Table 8). The height of albumen and HU of the RSM-PM groups were lower than those of the control groups (P < 0,05). In the first experiment the quality of albumen at the lowest protein level was better than at the other levels. The use of RSM has not generally been detrimental to albumen quality or shell strength (LESLIE and SUMMERS 1972, VOGT and STUTE 1974, BLAIR

Table 5. Feed consumption and efficiency of feed conversion (± SE)

	RSM level		Significance	Protein level (%)		
Expt. 1.	0	+		14,0	15,2	16,5
Feed g/hen/day	126,9 ± 0,54	127,5 ± 0,63	NS	126,2 ± 0,82	128,2 ± 0,65	127,3 ± 0,64
KJ ME/h/d	1294 ± 5,6	1284 ± 6,4	"	1284 ± 8,5	1299 ± 6,6	1285 ± 6,6
Crude protein g/h/d	19,4 ± 0,14	19,5 ± 0,18	"	17,7 ± 0,12[c]	19,5 ± 0,10[d]	21,1 ± 0,11[e]
kg feed/kg eggs	3,19 ± 0,038	3,29 ± 0,043	"	3,29 ± 0,050	3,22 ± 0,051	3,20 ± 0,049
MJ ME/kg eggs	32,5 ± 0,40	33,2 ± 0,44	"	33,6 ± 0,52	32,6 ± 0,53	32,4 ± 0,51
g protein/kg eggs	486 ± 6,3	502 ± 7,1	"	463 ± 7,0[c]	490 ± 7,6[c]	530 ± 8,2[d]
	RSM + PM					
Expt. 2.	0	+		13,6	15,0	16,3
Feed g/hen/day	127,6 ± 0,45	130,4 ± 0,58	XX	129,4 ± 0,59[a]	126,8 ± 0,53[b]	131,0 ± 0,75[a]
KJ ME/h/d	1308 ± 4,8	1306 ± 5,8	NS	1321 ± 6,1[c]	1284 ± 5,5[d]	1318 ± 6,9[c]
Protein g/h/d	19,2 ± 0,13	19,7 ± 0,19	XX	17,8 ± 0,08[c]	19,1 ± 0,08[d]	21,5 ± 0,14[e]
kg feed/kg eggs	3,14 ± 0,033	3,25 ± 0,039	NS	3,19 ± 0,044	3,18 ± 0,048	3,20 ± 0,042
MJ ME/kg eggs	32,2 ± 0,35	32,6 ± 0,40	"	32,7 ± 0,46	32,2 ± 0,50	32,3 ± 0,43
g protein/kg eggs	473 ± 5,7	490 ± 7,0	"	439 ± 6,0[c]	480 ± 7,2[d]	526 ± 7,1[e]

NS = non-significant
XX P < 0,01
a-b P < 0,05
c-d-e P < 0,01

Values with different superscript letters are significantly different.
If no letters are used the differences are non-significant.

Table 6. F-values of analysis of variance.

	d.f.[1]	Egg prod. %	Egg wt.	Prod./ g/day	Feed intake g/day	KJ/day	Protein/ day	Feed/ kg eggs	MJ/kg eggs	Protein/ kg eggs
Expt. 1.										
Treatments	5	0,68	0,51	1,57	2,54*	1,55	101,7***	1,40	1,31	8,84***
RSM level	1	0,90	0,46	2,30	0,48	0,10	0,66	3,36	2,17	3,30
Protein level	2	1,13	0,37	2,29	2,02	1,29	234,1***	1,71	1,28	20,0***
RSM × Prot.	2	0,15	0,69	0,49	4,01*	2,51	6,87**	0,93	0,91	0,55
Expt. 2.										
Treatments	5	0,24	0,49	0,61	11,2***	6,49***	183,4***	1,19	0,54	18,6***
RSM-PM level	1	0,03	1,44	0,60	15,6***	0,16	16,6***	4,59*	0,90	5,06*
Protein level	2	0,20	0,37	0,66	11,9***	12,6***	344,6***	0,07	0,25	41,7***
RSM-PM × Prot.	2	0,39	0,15	0,58	7,40**	3,30	27,2***	0,62	0,65	2,00

[1]d.f. of error: Expt. 1 210, Expt. 2 234

* P < 0,05
** P < 0,01
***P < 0,001

Table 7. Body weight and mortality of hens (± SD).[1]

	RSM level 0	RSM level +	Significance	Protein level 14,0/13,6	15,2/15,0	16,5/16,3	Significance
Expt. 1.							
Initial body wt. kg	1,99 ± 0,010	2,00 ± 0,11	NS	2,00 ± 0,014	2,01 ± 0,013	1,99 ± 0,012	NS
Final " "	2,18 ± 0,014	2,18 ± 0,014	"	2,19 ± 0,019	2,18 ± 0,017	2,17 ± 0,016	"
Wt.gain % "	9,4 ± 0,45	9,1 ± 0,52	"	9,6 ± 0,65	8,9 ± 0,55	9,3 ± 0,59	"
Mortality %	5,3 ± 1,3	8,3 ± 1,4	"	9,6 ± 2,0	4,6 ± 1,4	6,3 ± 1,5	"
	RSM+PM 0	+					
Expt. 2							
Initial body wt. kg	1,95 ± 0,009	1,95 ± 0,010	NS	1,96 ± 0,013	1,94 ± 0,012	1,96 ± 0,011	NS
Final " "	2,16 ± 0,013	2,09 ± 0,013	***	2,12 ± 0,016	2,11 ± 0,016	2,14 ± 0,015	"
Wt. gain %	10,5 ± 0,47	7,3 ± 0,46	***	8,2 ± 0,59	9,2 ± 0,61	9,2 ± 0,53	"
Mortality	1,9 ± 0,5	3,1 ± 0,6	NS	2,5 ± 0,8	1,3 ± 0,4	3,8 ± 0,7	"

SD = standard deviation
*** P <0,001

Table 8. Data of egg quality tests (± SD)

Expt. 1.	RSM level 0	+	Significance	Protein level Expt. 1/Expt. 2 (%). 14,0/13,6	15,2/15,0	16,5/16,3
Height of albumen mm	5,8 ± 1,2	5,8 ± 1,2	NS	6,0 ± 1,1^{a}	5,7 ±1,1^{b}	5,7 ± 1,3^{b}
HU	75,2 ± 9,6	75,2 ± 9,6	"	77,1 ±9,1^{a}	74,5 ± 9,0^{b}	74,4 ± 10,4^{b}
Spec. weight	1,0827	1,0825	"	1,0830	1,0824	1,0825
SD	0,0046	0,0042		0,0046	0,0047	0,0042
Expt. 2.						
Height of albumen	6,8 ± 1,0	6,7 ± 1,0	*	6,8 ± 1,2	6,8 ± 1,2	6,7 ± 1,2
HU	82,9 ± 8,3	81,8 ± 8,6	*	82,7 ± 8,4	82,6 ± 8,1	81,8 ± 8,9
Spec. weight	1,0838	1,0840	NS	1,0839	1,0834	1,0843
SD	0,0046	0,0044		0,0048	0,0044	0,0045

*
a–b P<0,05

Table 9. Effect of feeding rapeseed meal on thyroid weight (±SD) of laying hens.

RSM % (Expt. 1/Expt2)	0/0	5/4	8/8	11/12	RSM average	Significance
Expt. 1						
N	24	12	12	12	36	
Thyroid wt. (±SD)	158,5 ± 41,4^{ce}	188,0 ± 54,0^{cdef}	235,5 ± 50,1^{f}	199,1 ± 33,2^{d}	208,1 ± 5,0	P < 0,001***
Thyroid mg/100 g body wt.	7,2 ± 1,6^{ce}	8,5 ± 2,7^{cdef}	10,1 ± 2,3^{cdf}	9,0 ± 1,6^{def}	9,2 ± 2,2	"
Expt. 2						
N	17	17	17	17	51	
Thyroid wt.	166,6 ± 42,2^{abce}	223,7 ± 54,5^{adef}	245,4 ± 56,8^{abcdf}	271,5 ± 58,9^{bcdf}	246,9 ± 59,0	"
Thyroid mg/100 g body wt.	7,6 ± 2,0^{abe}	10,7 ± 2,5^{af}	11,7 ± 2,7^{abf}	12,9 ± 3,1^{bf}	11,8 ± 2,9	"

a-b P < 0,05
c-d P < 0,01 Values with different superscript letter in the same row are significantly different.
e-f P < 0,001

Table 10. Blood and serum values (± SD) in Expt. 1.

	RSM level				Protein level (%)				
	N	0	+	Significance	N	14,0	15,2	16,5	Significance
Hb g/l	27	17,1 ± 2,2	16,9 ± 2,0	NS	18	16,3 ± 1,5	17,5 ± 1,5	17,3 ± 3,1	NS
Haematocrit %	"	32,1 ± 2,8	31,7 ± 2,6	"	"	31,2 ± 2,8	32,6 ± 2,4	31,7 ± 2,3	"
Serum prot. g/l	"	46,7 ± 4,5	44,8 ± 3,0	"	"	44,4 ± 2,4	46,5 ± 3,7	46,2 ± 4,2	"
Serum alb. "	"	17,2 ± 1,6	17,4 ± 1,4	"	"	17,2 ± 1,0	17,7 ± 1,8	17,0 ± 1,5	"
SBI[1)] kg/100 ml	"	0,33 ± 0,13	0,31 ± 0,12	"	"	0,26 ± 0,11	0,35 ± 0,11	0,35 ± 0,13	"

[1)] serum protein-bound iodine

Table 11. Observations in the egg tasting tests.

Group 5 (RSM 0 %)/Group 6 (RSM 11–12 %)	Number of observations	%
G. 5 has better taste than G. 6	26	35
G. 6 has better taste than G. 5	18	24
No difference	30	41
	74	100

et al. 1975, Olomu et al. 1975, Thomas et al. 1978, Hulan and Prodfoot 1981). Neither has protein level had detrimental effects on albumen or shell quality (Kolstad and Lien 1974, El Boushy and Muilwijk 1978, Kiiskinen 1979).

The inclusion of Tower RSM in the diets increased the absolute and relative weights of the thyroid gland (Table 9). This increase was an average of 30 and 60 % (P < 0,01) in Experiments 1 and 2, respectively, and was approximately similar to that reported by Vogt and Torges (1976) and Thomas et al. (1978) with 10 % LG-RSM.

No significant differences in haematological or serum values could be found, although the content of serum protein in the RSM groups (Expt. 1) was approximately two percentage units lower than in the control groups (Table 10). The values of Hb and serum protein at the lowest protein level were lower than at the other levels.

According to the distribution of the opinions in the taste tests, RSM did not affect the taste of the eggs adversely. This was to be expected, because the "fishy" taint of eggs associated with the sinapine of RSM is mainly found in the eggs of certain breeds of hens laying brown eggs (Hobson-Frohock et al. 1973, 1977, Overfield and Elson 1975, Hawrysh et al. 1975).

The results of this and other studies indicate that rapeseed meal from low-glucosinolate cultivars may be incorporated in layers' diets at a level of 10–15 %. The protein level of layers' diets can be reduced to 13,5–14 %, even if only domestic protein reserves are available, for example in crisis situations. This does not need to cause any distinct decrease in egg production or profits. One must pay attention to the sufficiency of amino acids, and the ME content of the ration should be balanced according to the requirements.

REFERENCES

Andersson, S. & Elwinger, K. 1976. Försök med ärter till värphöns. Fjäderfä 69: 22–23.

Aulin, H. 1979. Tanniinipitoisuuden muuntelusta ja siihen vaikuttavista tekijöistä herneen (*Pisum sativum* L.) siemenissä. Kasvinjalostuslaitoksen tiedote 12: 34 p.

Blair, H., Robblee, A. R., Dewar, W. A., Bolton, W. & Overfield, N. D. 1975. Influence of dietary rapeseed meals and selenium on egg production and egg tainting in laying hens. J. Sci. Food. Agric. 26: 311–318.

Davidson, J. 1980. The nutritive value of field peas (*Pisum sativum*) in an oat-based diet for laying hens. J. Sci. Food. Agric. 31: 1055–1058.

El Boushy, A. R. & Muilwijk, I. 1978. Effect of varied protein levels with synthetic amino acids on performance of layers and egg quality. Feedstuffs Oct. 23: 15, 16, 50.

Fernandes, R., Salman, A. J. & McGinnis, J. 1973. Effect of feeding different protein levels and of changing protein level on egg production. Poult. Sci. 52: 64–69.

Grandhi, R. R., Slinger, S. J. & Summers, J. D. 1977. Productive performance and liver lesions in two strains of laying hens receiving two rapeseed meals. Poult. Sci. 56: 1904–1908.

Guillaume, J. 1977. Use of field beans (*Vicia faba* L.) and peas (*Pisum sativum*) in laying-hen and growing-chicken diets. Prot. Qual. Leg. Crops. Commission of the Eur. Communities ed., Eur. 5686 EN; 217–235. (Ref. Vogt etc. 1979).

– 1978. Nouvelles acquisitions sur l'utilisation de la féverole (*Vicia faba*) et au pois (*Pisum sativum*) dans l'alimentation de la volaille. Proc. XVI W. Poult. Congr. IV: 1128–1132.

Hawrysh, Z. J., Clandinin, D. R., Robblee, A. R., Hardin, R. T. & Darlington, F. 1975. Influence of rapeseed meal on the odor and flavour of eggs from different breed of chickens. J. Can. Inst. Food Technol. 8: 51–54.

Hermann, K. 1963. Deutsche Lebensmittel-Rundschau 59; 309–317.

Hobson-Frohock, A., Land, A. G., Griffits, N. M. & Curtis, R. F. 1973. Egg taints: association with trimethylamine. Nature 243: 304–305.

– , Fenwick, G. R., Heaney, R. K., Land, D. G. & Curtis, R. F. 1977. Rapeseed meal and egg taint: association with sinapine. Br. Poult. Sci. 18: 539–541.

Hulan, H. W. & Proudfoot, F. G. 1980. The nutritional value of rapeseed meal for caged layers. Can. J. Anim. Sci. 60: 139–147.

– & Proudfoot, F. G. 1981. Performance of laying hens fed diets containing soybean gums, rapeseed gums or rapeseed meals with and without gums. Can. J. Anim. Sci. 61: 1031–1040.

Kiiskinen, T. 1979. Pekilo in the feeding of poultry. The results of the experiments carried out in Finland. Res. Rep. Pekilo-symp. Tampere 1978. Inst. Anim. Husb. N:o 12: 133–143.

Kolstad, N. & Lien, S. 1974. Eggproduksjon of fôrutnyttelse ved ulike proteinnivåer i foret til verpehøner. Meld. fra Norges Landbrukshøgskole, 53, 34. 16 p.

Leslie, A. J. & Summers, J. D. 1972. Feeding value of rapeseed for laying hens. Can. J. Anim. Sci. 52: 536–566.

Lipinska, H. 1978. Rapeseed oil meals in feeding poultry. II Rapeseed meals from continuous and discontinuous extractions. Rocz. Nauk. Zoot. 10: 17–67.

March, B. E., Biely, J. & Soong, R. 1972. Rapeseed meal in the chicken breeder diet. Effects on production, mortality, hatchability and progeny. Poult. Sci. 51: 1581–1596.

Miller, E. C., Sunde, M. L. & Elvehjelm, C. A. 1957. Minimum protein requirement of laying pullets at different energy levels. Poult. Sci. 36: 681–690.

Moran, E. T., Summers, J. D. & Jones, G. E. 1968. Field peas as a major dietary protein source for the growing chick and laying hens with emphasis on high-temperature steam pelleting as a practical means of improving nutritional value. Can. J. Anim. Sci. 48: 47–55.

Muztar, A. J., Slinger, S. J., Likuski, H. J. A. & Dorrell, H. G. 1980. True amino acid availability values for soybean meal and Tower and Candle rapeseed and rapeseed meals determined in two laboratories. Poult. Sci. 59: 605–610.

National Research Council (NRC) Nutrient Requirements of Poultry. Seventh revised edition 1977, 62 p. Washington D.C.

Olaboro, G., Cambell, L. D. & Marqurdt, R. 1980. Performance of laying hens fed on diets containing heat-treated beans (*Vicia faba* L. var. *minor*), cotyledons and hulls. J. Agr. Sci. UK, 95: 697–701.

Olomu, J. M., Robblee, A. R., Clandinin, D. R. & Hardin, R. T. 1975. Effects of Span rapeseed meal on productive performance, egg quality, composition of liver and hearts and incidence of "fatty livers" in laying hens. Can. J. Anim. Sci. 55: 71–75.

OLSEN, O. & SØRENSEN, H. 1980. Sinalbin and other glucosinolates in seedes of double low rape species and *Brassica mapus* cv. Bronowski. J. Agric. Food. Chem. 28: 43–48.

OVERFIELD, N. D. & ELSON, A. A. 1975. Dietary rapeseed meal and the incidence of tainted eggs. Br. Poult. Sci. 16: 213–217.

RICHTER, G. 1981. Erbsen (*Pisum sativum* L.) als Mischfutterkomponente für Legehennen. Arch. Tierernähr. 31: 713–719.

ROBBLEE, A. R., CLANDININ, D. R., SLINGER, S. J. & SUMMERS, J. D. 1978. Rapeseed meal for poultry. Rapeseed Assoc. Of Canada Publ. No 51: 12–17.

SLINGER, S. J., SUMMERS, J. D. & LEESON, S. 1978. Utilization of meal from a new rapeseed variety *Brassica campestris* cv. Candle in layer diets. Can J. Anim. Sci. 58: 593–596.

STEEL, R. D. & TORRIE, J. H. 1960. Principles and Procedures of Statistics. 481 p. New York.

SUMMERS, J. D., RAJARATNAM, G. & PEPPER, W. F. 1971. Evaluation of rapeseed meal as a protein supplement for laying hen diets. Poult. Sci. 50: 1382–1386.

THIES, W. 1976. Fette Seifen Anstrichm. 6: 231–234.

THOMAS, D., ROBBLEE, A. R. & CLANDININ, D. R. 1978. Effects of low and high glucosinolate rapeseed meals on productive performance, egg quality, composition of liver and incidence of haemorrhagic liver syndrome in laying birds. Br. Poult. Sci. 19: 449–454.

THORNTON, P. A., BLAYLOCK, L. G. & MORENG, R. E. 1957. Protein level as a factor in egg production. Poult. Sci. 36: 552–557.

VOGT, H., SCHUBERT, H. J., STUTE, K. & RAUCH, W. R. 1969. Futterwert und Einsatz von Rapsschrot in der Geflügelfütterung. 3. Mitt. Arch. Geflügelk. 33: 119–124.

– & STUTE, K. 1974. Führt eine Senkung des Vinyl-Oxazolidinethion-Gehaltes zu einer Verbesserung des Fütterwertes von Rapsextraktionsschrot im Geflügelfutter? Arch. Geflügelk. 38: 127–138.

– TORGES, H-G. 1976. Rapsextractionsschrot aus einer erucasäure- und glucosinolatarmen Sommerrapssorte im Legehennenfutter. Arch. Geflügelk. 40: 225–231.

– , HARNISCH, S. & KRIEG, R. 1979. Der Einsatz von Erbsenschrot im Geflügelfutter. Arch Geflügelk. 43: 195–199.

Manuscript received January 1983

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SELOSTUS

Rapsijauhon käyttö erikseen ja yhdessä hernejauhon kanssa munivien kanojen lisävalkuaisrehuna

TUOMO KIISKINEN

Maatalouden Tutkimuskeskus

Vähän glukosinolaatteja sisältävän Tower rapsilajikkeen (00) uutettuja jauhoja käytettiin munivien kanojen rehussa 4/5, 8 ja 11/12 % rehun valkuaistasosta (13,5, 14,8 ja 16,2 %) riippuen kahdessa kokeessa, joista toisessa rehuihin sisällytettiin myös samat määrät hernejauhoa kuin rapsijauhoa. Rapsijauho korvasi ensimmäisessä kokeessa noin puolet lisävalkuaisesta ja toisessa kokeessa kaiken kala-ja soijajauhon. Kummassakin kokeessa oli jokaisessa ryhmässä 120 (4 × 30) kanaa ja kokeiden kestoajat olivat 9 ja 10 kk.

Rapsijauhon tai rapsi-hernejauhon käyttö ei vaikuttanut merkitsevästi munan tuotantoon millään valkuaistasolla. Myöskään valkuaistasojen välillä ei ollut merkitseviä eroja, vaikkakin ilmeisesti valkuaisen laadusta johtuvaa tuotannon laskua oli todettavissa ensimmäisen kokeen alimmalla valkuaistasolla. Toisessa kokeessa rapsihernejauhoryhmien painonlisäys oli merkitsevästi pienempi kuin vertailuryhmien. Lähinnä rehujen energiaväkevyyserojen vuoksi rapsi-herneryhmien rehunkulutus oli suurempi kuin vertailuryhmien. Molemmissa kokeissa rapsi- tai rapsi-hernerehuja kului n. 0,1 kg enemmän munakiloa kohden kuin vertailurehuja. Rapsijauhon käyttö lisäsi kilpirauhasen suhteellista painoa ensimmäisessä kokeessa keskimäärin 30 ja toisessa kokeessa 60 %.

Koetulosten mukaan kaksinolla-rapsilajikkeiden uutettuja jauhoja voidaan sisällyttää 10–15 %:iin saakka munivien kanojen täysrehuihin. Rehujen valkuaispitoisuuden alentamisen 13,5 – 14 %:iin pelkästään kotimaisen lisävalkuaisen varassa, ei tarvitse välttämättä aiheuttaa mitään huomattavaa tuotannon laskua. Aminohappojen riittävyydestä on huolehdittava sekä rehun energiapitoisuutta mahdollisuuksien mukaan nostettava rasvalisäyksellä.

ANNALES AGRICULTURAE FENNIAE, VOL. 22: 206–213 (1983)

Seria ANIMALLA DOMESTICA N. 64 – Sarja KOTIELÄIMET n:o 64

THE EFFECT OF DIETS SUPPLEMENTED WITH REGENT RAPESEED MEAL ON PERFORMANCE OF BROILER CHICKS

TUOMO KIISKINEN

KIISKINEN, T. 1983. **The effect of diets supplemented with Regent rapeseed meal on performance of broiler chicks.** Ann. Agric. Fenn. 22: 206–213. (Agric. Res. Centre, Inst. Anim. Husb., SF-31600 Jokioinen, Finland.)

Rapeseed meal (RSM) from the low-glucosinolate cultivar Regent was fed as 0, 8, 16 and 22 % of a broiler diet at two energy levels (11,2 and 12,1 MJ ME/kg). RSM replaced soybean meal (SBM). The inclusion of RSM in the diet decreased by c. 15 g ($P < 0,01$) the live weights of the broilers at the age of 2,5 weeks. The weight gain between the ages of 2,5 and 6 weeks did not, on the whole, differ between the RSM groups and the SBM controls. The growth rate and feed efficiency of the broilers were better ($P < 0,01$) at the ME level of 12,1 MJ than at the level of 11,2 MJ/kg. Mortality was not significantly affected by the dietary treatment. The relative weight of the thyroid gland increased by an average of 80 % when RSM was included in the diets ($P < 0,001$). Enlargement of the liver was also found in the RSM groups. The feeding of RSM was not found to affect the acceptability of broiler meat.

Index words: rapeseed meal, energy level, broiler chick, growth rate, mortality, thyroid weight, liver weight.

INTRODUCTION

Compared with soybean meal (SBM), dietary levels of 5–10 % rapeseed meals (RSM) extracted from the older high-glucosinolate (HG) cultivars have negatively affected the growth rate of chicks (SUMMERS et al. 1969, OLOMU et al. 1974, LIPINSKA 1978, YULE and MCBRIDE 1978, FRIS JENSEN and GAARDBO THOMSEN 1980). Meals from the new low-glucosinolate (LG) cultivars have clearly succeeded better than HG meals (MARANGOS et al. 1974, MOODY et al. 1978, SALMON 1979, CAMPBELL and SMITH 1979). LG meals have been used up to 15–30 % in experimental diets and growth of the chicks has generally been the same or slightly inferior to the SBM control (MOODY et al. 1978, SALMON et al. 1979, HULAN et al. 1980, HULAN and PROUDFOOT 1981, FRIS JENSEN and GAARDBO THOMSEN 1981, ELWINGER et al. 1981). Because the ME value of LG-RSM is lower than that of SBM the inclusion of LG-RSM is the diets of broiler chicks has often impaired feed efficiency if the diets have not been isocaloric.

This study was conducted to investigate the feeding value of Regent LG-RSM *(Brassica napus)* for broiler chicks. Rapeseed meal was compared with soybean meal at two energy levels.

MATERIAL AND METHODS

Animals and housing

A total of 2880 day-old broiler chicks of a commercial strain (Pilch) was randomly distributed into 32 floor pens so that each pen held 45 male and 45 female birds (15/m^2). The initial temperature was 33 °C and it was reduced by 2–3 °C weekly to 19 °C at five weeks of age. The birds were subjected to continuous lighting of 20 lux for the first 10 days and for the remainder of the experimental period the duration was reduced to 23 h and light intensity to 10–5 lux. Each pen was furnished with two cylindrical feed pans and one automatic waterer. Wood shaving was used as litter.

Experimental procedure

Treatments were allotted to pens in a 2 × 4 factorial design in which the factors were RSM levels (0, 8, 16 and 22 %) and energy levels (11,2 and 12,1 MJ ME/kg). Four pens were assigned to each dietary treatment. The total weight of day-old chicks in each pen was measured and individual weights measured at the ages of 19 and 40 days. Feed consumption was recorded for the periods between the weighings. In the slaughterhouse, the total weight of the carcasses from each pen was measured. Leg weakness was recorded in the broiler house. After the last weighing 17 birds per RSM level were randomly selected and killed. Their thyroid glands and livers were removed and weighed. In the slaughterhouse four sample carcasses per RSM level of 0, 16 and 22 % were chosen at random and frozen. The thawed carcasses were covered with aluminium foil and cooked in electric ovens (200 °C for 1,5 hours) without any spices. A panel of seven people at the Institute independently tasted for strange and unpleasant flavours in breast and thigh meat.

Table 1. Composition (%) of the experimental diets.

ME level MJ/kg	11.2				12.1			
RSM level %	0	8	16	22	0	8	16	22
Fish meal	5	——→						
Meat and bone meal	3	——→						
Pekilo	1	——→						
Soybean meal	15	10	5	–	15	10	5	–
RSM (Regent)	–	8	16	22	–	8	16	22
Barley (whole)	59	55,2	51,4	49,8	42,4	38,7	35,0	33,6
" (dehulled)	–	–	–	–	10	10	10	10
Wheat	–	–	–	–	20	20	20	20
Oats	15	15	15	15	–	–	–	–
Rapeseed oil	0,4	1,2	2,0	2,6	2,0	2,7	3,4	3,8
Limestone flour	0,5	——→						
Dicalcium phosphate	0,3	——→						
Sodium chloride	0,3	——→						
Mineral premix[1]	0,25	——→						
Vitamin premix[2]	0,15	——→						
DL-methionine	0,08	——→						
Crude protein % calc.	20,5	——→						
" " " anal.	20,0	19,8	20,1	19,8	19,9	20,1	20,0	20,4
Crude fat " "	3,5	4,4	5,9	7,0	4,6	5,4	7,2	7,7
Methionine " calc.	0,42	——→						
" " anal.	0,32	0,32	0,34	0,38	0,32	0,34	0,36	0,39
Lysine " calc.	1,10	——→						
" " anal.	1,06	0,95	0,94	1,07	1,05	1,13	0,98	1,00
Calcium " "	1,16	1,17	1,15	1,17	1,14	1,16	1,15	1,16
Phosphorus " "	1,05	0,98	0,98	1,07	1,10	0,89	0,99	0,98
ME MJ/kg calc.[3]	11,10	11,26	11,26	11,35	11,93	12,06	12,02	12,06

[1] Supplied per kg of diet: 20 mg Fe, 45 mg Zn, 48 mg Mn, 4 mg Cu, 0,16 mg Co, 0,5 mg I, 0,1 mg Se

[2] Supplied per kg of diet: 15000 IU vitamin A, 2000 IU vitamin D_3, 20 mg vitamin E, 1,5 mg vitamin K, 4,5 mg B_2, 3 mg B_6, 0,015 mg B_{12}, 22 mg niacin, 4,5 mg calcium pantothenate, 0,9 mg folic acid, 500 mg choline chloride, 0,075 mg biotin.

[3] ME value of 2 MJ/kg for RSM

Diets and feeding

All diets contained 5 % fish meal, 3 % meat and bone meal and 1 % Pekilo single cell protein (Table 1). Soybean meal was gradually replaced with RSM extracted from Regent lowglucosinolate (00) cultivar. An attempt was made to make the energy contents of the diets of each energy level isocaloric with supplementary rapeseed oil. This was not completely successful because RSM contained more oil than expected (Table 2). The difference between the ME levels was produced with oil supplementation and cereal composition. The diets were offered ad libitum as meal because no pelletizing plant was available.

Table 2. Analysis of Regent rapeseed meal.

Proximate Analysis	%
Dry matter	90,0
Crude protein in DM	39,0
" fat	8,1
" fibre	12,0
Ash	7,8
Glucosinolates in fat free DM	
Gluconapin	0,21
Glucobrassicanapin	0,22
Progoitrin	0,36
2-OH-4 pentenylgluc.	0,03
Amino acids	g/16gN
Methionine	1,7
Cystine	1,8
Lysine	5,6
Arginine	6,5
Histidine	2,0
Leucine	7,4
Isoleucine	3,7
Phenylalanine	4,5
Tyrosine	3,3
Threonine	4,4
Valine	4,9
Glycine	5,1
Alanine	4,9
Aspartic acid	7,6
Glutamic acid	18,1
Serine	4,5
Proline	7,1

Chemical and statistical analyses

The proximate analysis (Weende) was performed for the experimental diets and rapeseed meal (Tables 1 and 2). Amino acids and glucosinolates were determined as described in the author's earlier study (Kiiskinen 1983). Calcium was analysed with an atomic absorption spectrophotometer and phosphorus with a photometer after colour reaction with ammonium vanadate. Total fat in liver was determined by eluting it with dichloromethanemethanol according to the method of Maxwell et al. (1980).

Data were analysed using analysis of variance. Significances of differences between the means were generally assessed by Tukey's test (Steel and Torrie 1960). In the case of thyroid and liver weights, the t-test was used.

RESULTS AND DISCUSSION

Proximate analysis of the RSM revealed that the oil content of the meal was exceptionally high, although it should have been processed by conventional hexane extraction (Table 2). The distribution of glucosinolates was different from that of the Tower meal in the author's earlier study on laying hens (Kiiskinen 1983). The analysed crude protein contents were on average of 0,5 percentage units below the calculated values (Table 1). The supplemented oil was mixed satisfactorily because the differences in the fat contents between the diets corresponded to the differences between the formulae. The determined methionine contents were lower than the calculated level in all cases.

At the age of 2,5 weeks the mean live weights of the broilers fed with the RSM diets differed significantly ($P < 0,01$) from those fed with the control diets (Table 3). This was associated with the ME level of 11,2 MJ and there was significant interaction ($P < 0,01$) between the RSM and ME level in both sexes (Table 6). No differences in growth rate were found between the ME levels during this first phase. On the whole, the weight gain at the age interval of 19–40 days and the final body weight of the RSM groups did not differ significantly from the control

Table 3. Body weight and gain of broilers.

	RSM level (%)					
	0	8	16	22	$\overline{X}$	SE
ME-level MJ/kg			Males (19 days) body weight g			
11,2	457^{acA}	432^{abd}	438^{bcd}	413^{beC}	435	12,4
12,1	439^{B}	434	427	443^{D}	436	13,2
$\overline{X}$	447^{c}	433^{d}	433^{d}	429^{d}	435	9,1
SE	15,5	19,5	18,8	17,8		
			Males (40 days) body weight g			
11,2	1608^{a}	1557^{bA}	1565^{ab}	1564^{abC}	1573^{C}	32,0
12,1	1602^{cd}	1608^{cdB}	1577^{c}	1636^{dD}	1606^{D}	35,7
$\overline{X}$	1605^{acd}	1586^{abcd}	1571^{bc}	1604^{d}	1591	24,2
SE	49,1	44,6	53,8	44,8		
			Females (19 days) body weight g			
11,2	405^{c}	388^{d}	393^{cd}	374^{dA}	389	13,1
12,1	396	388	390	397^{D}	393	12,5
$\overline{X}$	401^{ac}	388^{d}	391^{bcd}	384^{d}	391	9,0
SE	15,4	19,6	18,5	18,1		
			Females (40 days) body weight g			
11,2	1314	1305	1326	1306^{A}	1312^{C}	30,2
12,1	1334	1331	1319	1347^{B}	1332^{D}	33,9
$\overline{X}$	1324	1317	1322	1324	1322	22,7
SE	42,5	46,0	49,9	42,7		
			Males weight gain (19–40 days) g			
11,2	1151	1125^{C}	1128	1151^{A}	1139^{C}	25,1
12,1	1163	1175^{D}	1149	1193^{B}	1171^{D}	28,2
$\overline{X}$	1158^{cd}	1153^{cd}	1139^{c}	1175^{d}	1156	19,1
SE	40,7	33,7	42,9	33,8		
			Females weight gain (19–40 days) g			
11,2	908	916	933	931	922^{C}	23,8
12,1	937	942	929	950	939^{D}	28,2
$\overline{X}$	922	928	931	940	930	18,4
SE	35,4	35,7	40,8	35,0		

SE = standard error
a – b P < 0,05
c – d – e P < 0,01
A – B P < 0,05
C – D P < 0,01

If means in the horizontal columns are not followed by the same small letter they are significantly different at the level of probability shown. Values with no letters do not differ significantly. The same applies the vertical columns with the big letters.

groups. At the ME level of 11,2 MJ the final body weight of the cocks in the RMS groups was on average of 3 % lower than that in the control groups. In fact there was an interaction ($P < 0,05$) between sex and RSM level in the weight gain (Table 6). This was obviously due to the greater response of the males to the decreased supply of protein and amino acids in the RSM groups. The growth rate of broilers at the ME level of 12,1 MJ was significantly ($P < 0,01$) higher in the later phase than that at the lower ME level.

The slaughter weight of the RSM groups was approximately 2 % lower than that of the control groups (Table 4). The tendency to decreased slaughter percentage when the RSM and ME level increased refers to increased abdominal fat in the carcasses. The number of second class carcasses had a tendency to increase according to the RSM and ME level. The inclusion of RSM did not affect mortality or incidence of leg weakness in this study (Table 4). Generally, even high contents of LG-RSM in broiler diets have not in-

Table 4. Slaughter results, mortality and incidence of leg weakness[1)].

ME level MJ/kg	0	8	16	22	$\bar{X}$	SE
	Slaughter weight comb. sexes g					
11,2	916	887	887	871	890	7,9
12,1	908	901	889	916	903	6,0
$\bar{X}$	912	894	888	894	897	4,9
SE	11,3	9,1	8,2	12,3	–	–
	Slaughter percentage					
11,2	64,0	63,5	62,0	62,1	62,9	0,40
12,1	62,4	61,7	62,1	61,7	61,9	0,34
$\bar{X}$	63,2	62,6	62,0	61,9	62,4	0,26
SE	0,53	0,69	0,51	0,35	–	–
	Second class %					
11,2	5,5	5,9	6,7	7,0	6,3	0,45
12,1	7,0	7,3	6,8	7,6	7,2	0,34
$\bar{X}$	6,2	6,6	6,8	7,3	6,7	0,28
SE	0,59	0,45	0,55	0,71	–	–
	Mortality %					
11,2	6,1	3,9	1,7	3,3	3,7	0,71
12,1	3,9	1,9	2,8	2,5	2,8	0,64
$\bar{X}$	5,0	2,9	2,2	2,9	3,3	0,45
SE	1,19	1,93	0,89	0,46	–	–
	Leg weakness %					
11,2	0,3	1,2	1,1	0,3	$0,7^{A}$	0,17
12,1	1,4	2,5	2,3	0,6	$1,7^{B}$	0,34
$\bar{X}$	$0,9^{ab}$	$1,9^{b}$	$1,7^{b}$	$0,4^{a}$	1,2	0,21
SE	0,46	0,30	0,48	0,21	–	–

[1)] See Table 3

a – b }
A – B } $P < 0,05$

creased mortality (Campbell and Smith 1979, Fris Jensen and Gaardbo Thomsen 1981, Salmon et al. 1981, Elwinger et al. 1981, Hulan and Proudfoot 1981). The frequency of leg weakness at the ME level of 12,1 MJ was higher ($P < 0,05$) than at the level of 11,2 MJ. The same trend was also found in the study by Kiiskinen and Andersson (1982).

Feed intake and calculated consumption of metabozable energy and protein decreased, though not significantly, with the inclusion of RSM in the diet (Table 5). This was clearly due more to the higher ME concentration of the RSM diets compared with the control diets than decreased acceptability of the former. The difference in feed intake between the two ME levels was not significant, but was apparent. The possible reason for the decreased rate of growth of the RSM groups during the first weeks was the lower protein consumption caused by the decreased feed intake.

Efficiency of feed and energy conversion was better in the RSM groups than in the control groups, reflecting the calculated ME values (Table 5). The differences were significant ($P < 0,01$) between the extreme levels. The difference in feed efficiency but not in energy efficiency was significant between the ME levels.

The average relative enlargement of the thyroid gland was 80 % ($P < 0,001$) as a result of the feeding of RSM (Table 7). This was relatively high but corresponding or even greater growth of the gland has been measured in some earlier studies with LG-RSM on broiler chicks (Vogt and Stute 1974, Elwinger and Alden 1977, Robblee et al. 1978). As in the present study, an increase in the relative weight of the liver has been found as a result of the inclusion of LG-RSM in the diet (Olomu et al. 1975, Elwinger and Alden 1977,

Table 5. Feed intake and efficiency of feed conversion. (± SE).

	RSM level (%)				ME level (MJ/kg)		
	0	8	16	22	11,2	12,1	Significance
Feed g/bird/day							
0–19 days	36,2 ± 0,22	34,6 ± 0,50	34,2 ± 0,49	34,2 ± 0,49	35,0 ± 0,42	34,3 ± 0,34	NS
20–40 "	102,9 ± 1,50	99,4 ± 0,74	99,6 ± 1,91	98,8 ± 0,70	101,8 ± 0,89	98,5 ± 0,90	"
MJ ME/bird/day							
0–19 days	0,42 ± 0,048	0,40 ± 0,065	0,40 ± 0,052	0,39 ± 0,064	0,39 ± 0,048	0,41 ± 0,041	"
20–40 "	1,19 ± 0,017	1,16 ± 0,014	1,16 ± 0,014	0,16 ± 0,015	1,15 ± 0,010	1,19 ± 0,010	"
Protein g/bird/day							
0–19 days	7,2 ± 0,05	6,9 ± 0,10	6,8 ± 0,10	6,7 ± 0,08	7,0 ± 0,08	6,9 ± 0,07	"
20–40 "	20,6 ± 0,03	19,9 ± 0,02	19,9 ± 0,04	19,8 ± 0,01	20,4 ± 0,02	19,7 ± 0,02	"
Kg feed/kg wt. gain	2,09 ± 0,024[c]	2,03 ± 0,032[cd]	2,03 ± 0,031[cd]	1,99 ± 0,026[d]	2,10 ± 0,016	1,98 ± 0,012	xx
MJ ME/kg wt. gain	24,1 ± 0,18[a]	23,7 ± 0,28[ab]	23,6 ± 0,16[b]	23,4 ± 0,07[b]	23,6 ± 0,19	23,8 ± 0,15	NS
kg feed/kg sl. wt.	3,12 ± 0,036[a]	3,03 ± 0,040[ab]	3,04 ± 0,050[ab]	2,98 ± 0,044[b]	3,12 ± 0,026	2,96 ± 0,024	x
MJ ME/kg sl. wt.	35,9 ± 0,40	35,4 ± 0,40	35,4 ± 0,35	34,9 ± 0,33	35,1 ± 0,29	35,6 ± 0,29	NS

a – b, x: $P < 0,05$

c – d, xx: $P < 0,01$

Table 6. Interaction between the factors (F-values).

	d.f.[1)]	Body weight (19 days) ♂♂	Body weight (19 days) ♀♀	Body weight (40 days) ♂♂	Body weight (40 days) ♀♀	Weight gain 19–40 days ♂♂	Weight gain 19–40 days ♀♀	Feed consumption g/bird/day ♂♂+♀♀	Feed consumption kg/kg wt. gain
RSM × ME	3	13,0***	6,87***	5,11**	2,43	1,94	2,04	2,92	0,46
Sex × RSM	3	0,36		2,15		2,80*		–	–
Sex × ME	1	0,08		0,39		0,82		–	–

1) d.f. of error: body weight and gain 1198 (♂♂), 1570 (♀♀), feed consumption 27.

Table 7. Thyroid and liver weights of broilers and fat content of livers (± SD).

RSM-level %	0	8	16	22	ME MJ/kg 11,2	ME MJ/kg 12,1
N	17	17	17	17	34	34
Thyroid weight mg	152,3 ± 71,0^{abe}	236,0 ± 99,6^{af}	316,2 ± 105,2^{bf}	270,8 ± 82,8^{abf}		
Thyroid wt. mg/ 100 g body wt.	10,6 ± 15,1^{e}	17,1 ± 7,5^{f}	21,9 ± 8,2^{f}	19,2 ± 6,9^{f}		
Liver weight g	35,1 ± 5,7	35,8 ± 8,1	40,1 ± 7,1	39,8 ± 6,6		
Liver wt. g/100 g body wt.	2,41 ± 0,29^{abc}	2,54 ± 0,39^{acd}	2,73 ± 0,34^{bd}	2,75 ± 0,33^{abd}		
Fat % in fresh liver	5,3 ± 1,2	5,3 ± 1,2	5,2 ± 1,0	4,5 ± 0,6	5,0±1,1	5,2±1,1

SD = standard deviation
a – b $P < 0,05$
c – d $P < 0,01$
e – f $P < 0,001$

CAMBELL and SMITH 1979). No significant differences could be found in the fat content of liver between the RSM or ME levels (Table 7).

According to the observations of the taste panel, the feeding of RSM did not have any adverse effect on the flavour of the meat (Table 8). However, it must be mentioned that the members of the panel were not trained in their task. Usually, the corresponding contents of LG-RSM together with fish meal have resulted in a decreased taste score in trained panels (HAWRYSH et al. 1980, FRIS JENSEN and GAARDBO THOMSEN 1981, SALMON et al. 1981, AHLEN et al. 1981).

The results of the present study suggest that rapeseed meal from low-glucosinolate cultivars can be included up to 15–20 % to replace soybean meal in the diets of broiler chicks. This has also been confirmed in some earlier studies (SALMON et al. 1979, FRIS JENSEN and GAARDBO THOMSEN 1981, ELWINGER et al. 1981, HULAN and PROUDFOOT 1981). According to this study LG-RSM is best suited for use in the finisher feed after the age of 2,5–3 weeks. Compared with soybean meal, the lower ME value of rapeseed meal apparently requires more supplementary fat.

Table 8. Observations of the taste panel.

RSM level %	Number of observations 0	16	22
unpleasant flavour	8	–	3
fishy flavour	2	5	1
oily flavour	3	1	3
	13	6	7

REFERENCES

AHLEN, K., ELWINGER, K., SÄTERBY, B. & THOMKE, S. 1981. Slaktbedömning av slaktkycklingar uppfödda på foder med stigande halter av rapsmjöl. Fågelköttproduktion 3: 12–22.

CAMBBELL, L. D. & SMITH,. T. K. 1979. Responses of growing chickens to high dietary contents of rapeseed meal. Br. Poult. Sci. 20: 231–237,

ELWINGER, K. & ALDÉN, S. 1977. Försök med rapsmjöl till broiler. Lantbrukshögskolan, Inst. för husdjurens utfodring och vård. Uppsala, Stencil, 13 p.

– , AHLEN, K. & THOMKE, S. 1981. Försök nr 4 med rapsmjöl till slaktkycklingar. Fågelköttproduktion 2: 17–23.

FRIS JENSEN, J. & GAARDBO THOMSEN, M. 1980. Rapskrå og avoparcin i slagtekyllingefoder. Statens Husdyrbrugsforsøg Medd. 329. 4 p.

– & GAARDBO THOMSEN, M. 1981. Rapskrå (Line) nitrovin og avoparcin till slaktekyllinger. Statens Husdyrbrugsforsøg Medd. 358. 4 p.

HAWRYSH, Z. J., STEEDMAN-DOUGLAS, C. C., ROBBLEE, A. R., HARDIN R. T. & SAM, R. M. 1980. Influence of low glucosinolate (cv. Tower) rapeseed meal on the eating quality of broiler chickens. I Subjective evaluation by a trained test panel and objective measurements. Poult. Sci. 59: 550–557.

HULAN, H. W., PROUDFOOT, F. G. & MCRAE, K. B. The nutritional value of Tower and Candle rapeseed meals for turkey broilers housed under different lighting conditions. Poult. Sci. 59: 100–109.

– & PROUDFOOT, F. G. 1981. Replacement of soybean meal in chicken broiler diets by rapeseed meal and fish meal complementary sources of dietary protein. Can. J. Anim. Sci. 61: 999–1004.

KIISKINEN, T. 1983. Use of Tower rapeseed meal separately and together with pea meal to replace fish and soybean meal in layers' diet at varying protein concentrations. Ann. Agric. Fenn. 22: 195–205

– & ANDERSSON, P. 1983. The incidence of tibial dyschondroplacia in two broiler strains and their performance on different diets. Ann. Agric. Fenn. 22: 169–175.

LIPINSKA, H. 1978. Rapeseed oil meals in feeding poultry. Rocz. Nauk. Zoot. 10: 5–128.

MARANGOS, A., HILL, R., LAWS, B. M. & MUSCHAMP, D. 1974. The influence of three rapeseed meals and a mustard seed meal on egg and broiler production. Br. Poult. Sci. 15: 405–414.

MAXWELL, R. J., MARMER, W. N., ZUBILLAGA, M. P. & DALICKAS, G. A. 1980. Determination of total fat in meat and meat products by a rapid column method. J. Assoc. Off. Anal. Chem. 60: 600–603.

MOODY, D. L., SLINGER, S. J., LEESON, S. & SUMMERS, J. D. 1978. Utilization of dietary Tower rapeseed products by growing turkeys. Can. J. Anim. Sci. 58: 585–592.

OLOMU, J. M., ROBBLEE, A. R. & CLANDININ, D. R. 1974. Effects of processing and amino value of rapeseed for broilers. Poult. Sci. 53: 175–184.

– , ROBBLEE, A. R., CLANDININ, D. R. & HARDIN, R. T. 1975. Utilization of full-fat rapeseed and rapeseed meals in rations for broiler chicks. Can J. Anim. Sci. 55: 461–466.

ROBBLEE, A. R., CLANDININ, D. R., SLINGER, S. J. & SUMMERS, J. D. 1978. Rapeseed meal for poultry. Rapeseed Assoc. of Canada Publ. 51: 12–17.

SALOMON, R. E. 1979. Rapeseed meal in turkey starter diets. Poult. Sci. 58: 410–415.

– , KLEIN, K. K. & LARMOND, E. 1979. Low glucosinolate rapeseed meal in turkey broiler diets of varying nutrient density. Poult. Sci. 58: 1514–1523.

STEEL, R. D. & TORRIE, J. H. 1960. Principles and Procedures of Statistics. 481 p. New York.

SUMMERS, J. D., BAYLEY, H. S., PEPPER, W. F. & SLINGER, S. J. 1969. The value of rapeseed meal for growing pullets and laying hens. Can. J. Anim. Sci. 49: 97–103.

Manuscript received January 1983

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SELOSTUS

Niukasti glukosinolaatteja sisältävän rapsijauhon käyttömahdollisuudet broilereiden rehussa

TUOMO KIISKINEN

Maatalouden tutkimuskeskus

Broilereilla suoritetussa kokeessa korvattiin soijaa asteittain Regent kevätrapsilajikkeesta (00) uutetulla jauholla, jonka rasvapitoisuus oli poikkeuksellisen korkea. Rapsijauhon pitoisuudet olivat 0, 8, 16 ja 22 % rehussa, ja sen lisäksi kokeessa tutkittiin kahta muuntokelpoisen energian tasoa (11,2 ja 12,1 MJ/kg).

Koetulosten perusteella kaksinollalajikkeen uutetut jauhot soveltuvat hyvin valkuaisraaka-aineeksi soijan tilalle, varsinkin broilereiden kakkosrehuun, jota käytetään 2,5–3 ikäviikon jälkeen. Rapsijauho sisältää vähemmän muuntokelpoista energiaa kuin soijajauho, mikä on otettava huomioon rehuseoksia kokoonpantaessa. Rapsijauhon vaikutus kilpirauhaseen tuli selvästi esille rauhasen painon n. 1,8-kertaisena suurentumisena. Kuolleisuuteen ei rapsijauhon käytöllä kuitenkaan ollut vaikutusta.

ANNALES AGRICULTURAE FENNIAE, VOL. 22: 214–220 (1983)

Seria ANIMALIA DOMESTICA N. 65 – Sarja KOTIELÄIMET n:o 65

WHEAT PROTEIN CONCENTRATE AS A SUPPLEMENTARY PROTEIN SOURCE FOR BROILER CHICKS

Tuomo Kiiskinen

Kiiskinen, T. 1983. **Wheat protein concentrate as a supplementary protein source for broiler chicks.** Ann. Agric. Fenn. 22: 214–220. (Agric. Res. Centre, Inst. Anim. Husb., 31600 Jokioinen, Finland.)

Wheat protein concentrate (WPC) containing 45,5 % crude protein in dry matter was tested on broiler chicks. Four dietary levels of 0, 6, 12,5 and 19 % WPC were used with or without amino acid supplementation (methionine, lysine), gradually replacing soybean meal (SBM) in the diets. Inclusion of WPC in the diets significantly ($P < 0{,}01$) reduced the body weight of the broilers at three weeks of age. In addition the final body weight, weight gain during the last period of 3–6 weeks and slaughter weight decreased drastically with the two highest WPC levels compared with the two lowest levels ($P < 0{,}01$). The detrimental effects of WPC on the growth rate of chicks is mainly attributed to its low lysine content (2,9 g/16gN). The supplementation of amino acids significantly improved ($P < 0{,}01$) the growth of birds and the response increased ($P < 0{,}01$) when the WPC level increased. However, the growth rate of the chicks fed 12,5 and 19 % WPC in diets supplemented with amino acids did not reach the level of the control group.

Feed intake decreased significantly ($P < 0{,}01$) with the 12,5 and 19 % WPC diets compared with the SBM control. Feed efficiency also declined with the two highest WPC levels. The amino acid supplementation significantly ($P < 0{,}05$) improved feed consumption and efficiency.

The results of the study suggest that WPC is best suited for broiler finisher feeds at a limited concentration of 5 %.

Index words: wheat protein concentrate, methionine and lysine supplementation, broiler chick, growth.

INTRODUCTION

Wheat protein, like cereal proteins as a whole, is deficient in some amino acids. This concerns lysine, in particular, because its concentration varies, according to different sources, from 2,5 to 3,5 % (g/16gN) in wheat protein, and the requirement of starting chicks is 5 % of dietary protein (NRC 1977, Scott 1982). Lysine supplementation has produced a considerable response in the growth of chicks when their diet is based on wheat or wheat and soybean meal (Poppe et al. 1967, Gardiner and Dubetz 1976). The methionine content of wheat protein is 1,6–1,7 % and the requirement of chicks for this amino acid is 2 % in protein (NRC 1977, SCOTT 1982). According to BRAGG and AKINWANDE (1973) threonine and valine are also limiting amino acids in wheat protein. The biological value of wheat protein is 59 % and that of barley and oats, which contain more lysine than wheat, is approximately 70 % (EGGUM 1968).

The wheat starch industry in Finland produces a by-product which contains approximately 40 % crude protein composed of gliadine, albumen and globulin fractions of wheat protein. This product has been used in broiler diets and the purpose of this study was to test its availability as a source of supplementary protein for broiler chicks.

MATERIAL AND METHODS

Commercial, day-old, sexed broiler chicks (Pilch) were used in a 2 × 4 factorial experiment. Four levels of the wheat protein concentrate (WPC), 0, 6, 12,5 and 19 % in the diet, were used with or without amino acid supplementation. The chicks were distributed into 32 floor pens (6 m^2) so that each pen contained 12 males and 12 females. The average body weight was then 30 g. Four pens were alloted for each dietary treatment. The housing conditions were maintained at the same levels as in the author's earlier study (KIISKINEN 1983). The chicks were fed and watered ad libitum.

All diets contained 5 % fish meal and WPC gradually replaced soybean meal (SBM, Table 1). According to the producers information, the WPC contained lysine 3,7 – 3,8 g/16gN and methionine 1,9 – 2,1 g/16gN. The amino acid supplementations of the diets were defined on the basis of this information. Lysine was supplied with the two highest WPC levels. The diets were in pellet form (diameter 3 mm).

The birds were weighed individually at the ages of 3 and 6 weeks and feed intake was measured for each pen between the weighings. Mortality was recorded. In the slaughterhouse the total weight of each sex in every pen was measured.

The proximate analyses of the diets and WPC were performed and amino acids were determined with a gas chromatograph (Hewlett Packard 5710). The statistical significance of differences in body weight and feed consumption was established by analysis of variance and by Tukey's test (STEEL and TORREY 1960).

RESULTS AND DISCUSSION

According to the results of the analysis, the crude protein content of the diets was only 17,3 – 18,3 %, or approximately two percentage units below the calculated value (Table 1). This was partly affected by the exceptionally low protein content (60 %) of the fish meal used. The lysine content of the WPC (2,9 g/gN) was typical of wheat protein and considerably lower than that stated by the producer (Table 2). It was thus mainly for this reason that the lysine level of the diets was below the calculated values and, in most of the diets, was below the recommended value given above.

On the whole the growth rate of the birds was relatively low due to the low protein content of the diets and the low initial weight (30 g) of the chicks (Tables 3 and 4). According to KORELESKI and RYS (1979) the protein content of the broiler starter feeds ought not to be lower than 18 – 19 % and that of the finisher feeds 16 – 17 %, even when the methionine and lysine requirements are met. During the first three weeks the growth of the broilers decreased drastically ($P < 0,01$) when the content of WPC increased in the diets. The final body weight and slaughter weight of the WPC groups were also lower than those of the control group and the differences between the 12,5 and 19 % WPC levels and the SBM control were significant ($P < 0,01$). The weight gain from three to six weeks

Table 1. Composition (%) and calculated and analysed contents of experimental diets.

Diet	1	2	3	4	5	6	7	8
Fish meal	5,0	→						
Soybean meal	18,0	12,0	6,0	–	18,0	12,0	6,0	–
Wheat protein	–	6,0	12,5	19,0	–	6,0	12,5	19,0
Wheat	20,0	→						
Barley	40,0	→						
Oats	10,0	10,0	9,5	9,0	10,0	10,0	9,5	9,0
Rapeseed oil	2,6	→						
$CaCO_3$	1,0	→						
$CaHPO_4$	1,7	→						
NaCl	0,3	→						
DL-methionine	–	–	–	–	0,05	0,05	0,025	–
L-lysine	–	–	–	–	–	–	0,07	0,14
Vitamin premix[1)]	0,25	→						
Mineral premix[2)]	0,3	→						
Moisture % anal.	14,2	13,5	13,9	13,7	12,1	13,3	13,8	13,3
Crude protein % calc.	19,7	19,6	19,6	19,7	19,7	19,6	19,6	19,7
Crude protein % anal.	17,3	18,1	18,3	17,9	18,2	17,9	17,9	17,4
Crude fat % anal.	5,1	5,4	5,4	5,7	5,3	5,5	5,6	5,8
Crude fibre % anal.	4,1	3,9	3,6	3,4	4,1	3,9	3,7	3,5
Ash % anal.	5,6	5,3	5,0	4,9	5,7	5,5	5,2	5,2
ME MJ/kg % calc.	11,7				11,7			
Methionine % calc.	0,36	0,37	0,39	0,40	0,41	0,42	0,41	0,40
Lysine % calc.	1,06	1,00	0,93	0,86	1,06	1,00	1,00	1,00

[1)] Supplies per kg: Vit. A 15000 IU, vit D_3 2000 IU, vit E 25 mg, K_3 1,5 mg, B_2 3,5 mg, B_6 1,5 mg, B12 0,010 mg, niacin 22 mg, folic acid 0,6 mg, biotine 0,05 mg, choline 1000 mg
[2)] Supplies mg per kg: Fe 25, Zn 55, Mn 60, Cu 5, Co 0,5, I 0,5, Se 0,1

Table 2. Amino acid composition of wheat protein and experimental diets.[1)]

	Wheat protein	g/16 g N Diet 1	2	3	4	5	6	7	8
Methionine	1,7	1,8	1,9	1,9	1,9	2,0	2,1	2,1	2,0
Lysine	2,9	5,2	4,2	3,5	3,4	4,8	4,4	4,6	5,1
Arginine	5,0	6,2	5,0	4,3	4,5	5,2	5,6	5,3	5,5
Isoleucine	4,2	5,5	4,5	4,2	4,1	3,9	4,5	4,3	4,4
Leucine	7,2	8,1	7,3	7,1	6,8	6,6	7,2	7,0	7,2
Phenylalanine	5,3	5,1	4,5	4,5	4,3	4,3	4,7	4,6	4,6
Tyrosine	3,3	3,8	3,2	3,5	3,0	3,1	3,4	3,3	3,2
Threonine	3,3	4,5	3,9	3,6	3,5	3,4	3,8	3,6	3,7
Valine	5,4	6,3	5,6	5,2	5,3	4,4	5,1	4,9	5,4
Glycine	3,7	5,3	4,9	4,5	4,0	4,1	4,2	3,9	4,6
Alanine	4,0	5,4	5,1	4,7	4,2	4,1	4,3	3,9	4,4
Asp. acid	5,9	9,5	7,4	6,6	6,0	7,5	8,1	7,1	6,6
Glut. acid	22,2	20,3	19,0	19,9	20,2	17,6	19,0	20,7	20,3
Proline	7,7	7,1	7,1	7,5	7,5	6,2	6,5	7,3	7,6
Serine	4,2	5,3	4,6	4,4	4,1	4,2	4,5	4,2	4,4

[1)] Cystine and histidine values were unreliable.

Table 3. Body weight gain and slaughter weight of male broilers.[1)]

Suppl. amino acids	Wheat protein % 0	6	12,5	19	$\bar{X}$	SE
			Body weight g (3 weeks)			
0	355^{cA}	310^{dA}	241^{eC}	182^{fC}	280^{C}	6,5
+	391^{cB}	346^{dB}	310^{eD}	277^{eD}	333^{D}	5,4
$\bar{X}$	373^{c}	327^{d}	277^{e}	232^{f}	307	4,5
SE	6,5	6,3	6,1	7,8		
			Body weight g (6 weeks)			
0	1450^{c}	1394^{cA}	1111^{dC}	802^{eC}	1222^{C}	23,6
+	1531^{c}	1500^{cB}	1351^{dD}	1142^{eD}	1390^{D}	16,6
$\bar{X}$	1490^{c}	1444^{c}	1236^{d}	980^{e}	1306	15,2
SE	15,5	19,6	21,5	26,2		
			Weight gain 3 – 6 weeks			
0	1095^{c}	1084^{c}	871^{dC}	620^{eC}	942^{C}	17,9
+	1140^{c}	1154^{c}	1041^{dD}	865^{eD}	1056^{D}	12,9
$\bar{X}$	1117^{c}	1117^{c}	959^{d}	749^{e}	999	11,5
SE	12,3	15,1	16,6	19,7		
			Slaughter weight g			
0	888^{c}	825^{c}	665^{dC}	478^{eC}	714^{C}	41,9
+	878^{c}	894^{c}	803^{dD}	698^{eD}	818^{D}	22,5
$\bar{X}$	883^{c}	859^{c}	734^{d}	588^{e}	766	25,2
SE	22,1	15,3	28,8	42,4		

[1)] Means not having the same superscript letter differ significantly:

horizontal columns	a – b	$P < 0,05$	SE = standard error
	c – d – e – f	$P < 0,01$	
vertical columns	A – B	$P < 0,05$	
	C – D	$P < 0,01$	

Table 4. Body weight gain and slaughter weight of female broilers.[1)]

Suppl. amino acids	Wheat protein % 0	6	12,5	19	$\bar{X}$	SE
			Body weight g (3 weeks)			
0	327^{cC}	306^{cA}	230^{dC}	177^{eC}	258^{C}	5,6
+	376^{cD}	337^{dB}	297^{eD}	278^{eD}	320^{D}	4,8
$\bar{X}$	350^{c}	321^{d}	263^{e}	224^{f}	288	4,1
SE	6,4	6,0	5,3	7,1		
			Body weight g (6 weeks)			
0	1238^{c}	1235^{c}	1016^{dC}	748^{eC}	1052^{C}	18,1
+	1325^{c}	1293^{d}	1191^{eD}	1027^{fD}	1206^{D}	13,4
$\bar{X}$	1279^{c}	1263^{c}	1101^{d}	878^{e}	1126	12,2
SE	15,8	16,6	14,8	20,2		
			Weight gain 3 – 6 weeks			
0	911^{c}	930^{c}	785^{dC}	571^{eC}	795^{C}	13,3
+	949^{c}	956^{c}	894^{dD}	749^{eD}	886^{D}	10,3
$\bar{X}$	929^{c}	942^{c}	839^{d}	654^{e}	838	8,9
SE	12,4	12,5	11,0	14,5		
			Slaughter weight g			
0	726^{c}	728^{c}	592^{d}	379^{eC}	606^{C}	38,9
+	852^{ac}	767^{acd}	709^{bd}	595^{bdD}	731^{D}	28,1
$\bar{X}$	789^{c}	748^{c}	650^{d}	487^{e}	668	26,1
SE	36,6	17,2	22,6	47,4		

[1)] See Table 3.

a – b	$P < 0,05$
c – d – e – f	$P < 0,01$
A – B	$P < 0,05$
C – D	$P < 0,01$

of age did not differ between the control and the 6 % WPC diet and it was significantly ($P < 0,01$) better than with the 12,5 and 19 % WPC diets.

Supplementation of amino acids produced a considerable increase in the growth rate of the chicks ($P < 0,01$). The response in the performance of the birds to the supplementation increased ($P < 0,001$) when the WPC content increased (Table 6). However, the performance of chicks fed WPC supplemented with amino acid did not reach the level of the control group. It seems very clear that methionine supplementation is necessary in broiler diets which contain restricted amount of fish meal; supplementary methionine alone increased the growth rate of the broilers on the control and 6 % WPC diets. Exclusive lysine supplementation improved the weight gain of the chicks on the 19 % WPC level ($P < 0,01$). Apparently methionine supplementation, in addition to lysine, might have improved the results. There was a significant sex × WPC level interaction ($P < 0,05$) in weight gain during the last period (Table 6).

Feed intake during the last three-week period de-

Table 5. Feed consumption and conversion of broilers (comb. sexes)[1)]

Suppl. amino acids	Wheat protein % 0	6	12,5	19	$\bar{X}$	SE
	Feed cons. g/d/bird 0 – 3 weeks					
0	45,1	45,8	45,5	44,0	45,1	0,91
+	48,1	44,7	44,8	45,1	45,7	0,98
$\bar{X}$	46,6	45,2	45,1	44,6	45,4	0,66
S.E	1,67	1,31	0,76	1,50,		
	Feed cons. g/d/bird 3 – 6 weeks					
0	$93,7^{c}$	$88,5^{cd}$	$81,7^{d}$	$77,7^{e}$	$85,4^{A}$	1,89
+	$94,2^{a}$	$90,2^{ab}$	$87,6^{ab}$	$84,6^{b}$	$89,1^{B}$	1,17
$\bar{X}$	$93,9^{c}$	$89,4^{cd}$	$84,6^{d}$	$81,2^{e}$	87,3	0,65
SE	0,47	0,99	1,68	2,40		
	Crude prot. g/d/bird 0 – 3 weeks					
0	7,8	8,3	8,3	7,9	8,1	0,68
+	8,8	8,0	8,0	7,9	8,2	0,74
$\bar{X}$	8,3	8,1	8,2	7,9	8,1	0,12
SE	0,33	0,24	0,15	0,26		
	Crude prot. g/d/bird 3 – 6 weeks					
0	$16,2^{c}$	$16,0^{c}$	$14,9^{cd}$	$13,9^{d}$	$15,3^{A}$	0,30
+	$17,1^{c}$	$16,2^{cd}$	$15,7^{cd}$	$14,7^{d}$	$15,9^{B}$	0,26
$\bar{X}$	$16,7^{c}$	$16,1^{cd}$	$15,3^{ade}$	$14,3^{be}$	15,6	0,20
SE	0,19	0,17	0,27	0,39		
	Feed conv. kg/kg weight gain					
0	$2,24^{c}$	$2,28^{c}$	$2,67^{c}$	$3,64^{d}$	$2,71^{A}$	0,159
+	$2,22^{ab}$	$2,19^{a}$	$2,32^{ab}$	$2,78^{b}$	$2,38^{B}$	0,074
$\bar{X}$	$2,23^{c}$	$2,24^{c}$	$2,49^{c}$	$3,21^{d}$	2,54	0,091
SE	0,041	0,050	0,072	0,217		
	Feed conv. kg/kg slaught. weight					
0	$3,67^{c}$	$3,75^{c}$	$4,37^{c}$	$6,39^{d}$	$4,54^{C}$	0,304
+	$3,60^{a}$	$3,50^{a}$	$3,79^{ab}$	$4,51^{b}$	$3,85^{D}$	0,114
$\bar{X}$	$3,64^{c}$	$3,63^{c}$	$4,08^{c}$	$5,45^{d}$	4,20	0,171
SE	0,139	0,231	0,316	1,198		

[1)] See Table 3. Values with no superscript letters do not differ significantly.

a – b	$P < 0,05$
c – d – e	$P < 0,01$
A – B	$P < 0,05$
C – D	$P < 0,01$

Table 6. Interactions between the factors (F-ratios).

	d.f.[1]	Body weight (3 wks) ♂♂	Body weight (3 wks) ♀♀	Body weight (6 wks) ♂♂	Body weight (6 wks) ♀♀	Weight gain ♂♂	Weight gain ♀♀	Slaughter wei ♂♂	Slaughter wei ♀♀
WPC × suppl. amino acids	3 (310)	6,25***	8,57***	12,8***	12,3***	11,6***	9,65***	10,6***	2,[illegible]
Sex × WPC	2 (623)	0,73		2,39		3,72*			
Sex × suppl.amino acids	1 (625)	1,18		0,01		0,31			
Sex × WPC × suppl. amino acids	3 (621)	0,60		0,59		0,93			
		Feed intake 0–3 wks	Feed intake 3–6 wks	Protein intake 0–3 wks	Protein intake 3–6 wks	Feed kg/kg wg		Feed kg/kg	
WPC × suppl. amino acids	3 (24)	0,43	1,25	1,38	0,52	4,85**		9,41***	

[1] df of error in brackets
* P < 0,05
** P < 0,01
*** P < 0,001

Table 7. Mortality of broilers receiving the various dietary treatments.

Age	Wheat protein % 0	6	12,5	19	F-ratio significance		Suppl. amino acids 0	+	F-ratio significance	
	Mortality (%)						Mortality (%)			
0 – 3 weeks	16,1	14,0	14,0	21,4	0,75	NS	14,8	18,0	0,62	NS
0 – 6 weeks	16,7	15,1	14,0	22,9	0,99	NS	14,8	19,5	1,40	NS

creased (P < 0,05) when the WPC level increased, especially if no amino acids were added (Table 5). Clearly, the unbalanced amino acid composition of the WPC diets negatively affected feed consumption. A review by Li and Anderson (1983) supports the proposal of a role for amino acids in both qualitative and quantitative aspects of food intake regulation. The other possible reason for the negative effect on feed consumption is the differences in the ME contents of the diets. WPC apparently has a higher ME value than SBM.

As a result of the decreased feed intake the supply of protein decreased significantly more (P < 0,01) at the two highest WPC levels than with the control. The efficiency of feed conversion at the two highest WPC levels was clearly inferior to the control and 6 % WPC diets. The difference between the 19 % WPC level and the two lowest levels (0 and 6 %) was significant (P < 0,01). The interaction between the WPC level and the use of supplementary amino acids was significant (P < 0,01) in the feed efficiency (Table 6).

Mortality was relatively high in this experiment and most of it occurred during the first three or four days (Table 7). Mortality was concentrated in some pens. No significant differences in mortality were ascertained between the treatments. The chick material was not very good in this study, as shown by the low initial weight, too.

The results of this investigation suggest that wheat protein concentrate can be used in limited amounts as a protein source for broiler chicks. This is principally due to the low lysine content of wheat protein. WPC is best suited for use in broiler finisher feeds at a concentration of approximately 5 %, supplemented with methionine and replacing soybean meal.

REFERENCES

Bragg, D. B. & Akinwande, A. J. 1973. The nutritional value of wheat protein for early growth of layer and broiler breeder pullets. Poult. Sci. 52: 1646–1651.

Eggum, B. O. 1968. Aminosyrekoncentration og proteinkvalitet. 90 p. København.

Gardiner, E. E. & Dubetz, S. 1976. Performance of broiler chicks fed two dietary protein levels (18 and 22 %), two Neepawa wheats (14,5 and 21,0 % protein), and six L-lysine levels. Can.

J. Anim. Sci. 56: 769–773.

KIISKINEN, T. 1983. The effect of diets supplemented with Regent rapeseed meal on performance of broiler chicks. Ann. Agric. Fenn. 22: 206–213.

KORELESKI, J. & RYS, R. 1979. Effect of reduced dietary protein and amino acid levels on the performance of broiler chickens. Feedstuffs, Sept. 17: 39–42.

LI, E. T. S. & ANDERSON, G. H. 1983. Amino acids in the regulation of food intake. Nutr. Abstr. and Rev. Ser. A. 53: 169–181.

National Research Council (NRC). Nutrient Requirements of Poultry. Seventh revised edition 1977, 62 p. Washington D.C.

POPPE, S., KRISTEN, H. & MEIER, H. 1967. Zum Einsatz synthetischer Aminosäuren bei Hühnerküken. 2. Ergänzung des Weizenproteins durch synthetische Aminosäuren. Arch. Geflügelzucht Kleintierk. 16: 213–219.

SCOTT, M. L. 1982. Dietary nutrient allowances for chickens, turkeys. Feedstuffs. Reference Issue 54: 57–58.

STEEL, R. D. & TORRIE, J. H. 1960. Principles and Procedures of Statistics. 481 p. New York.

Manuscript received Mars 1983

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SELOSTUS

Vehnävalkuaistiiviste broilereiden lisävalkuaisrehuna

TUOMO KIISKINEN

Maatalouden tutkimuskeskus

Kotimaisen tärkkelysteollisuuden sivutuotteena syntyvä vehnävalkuaistiiviste sisälsi raakavalkuaista 45,5 % kuiva-aineesta sekä lysiiniä 2,9 ja metioniinia 1,7 % valkuaisesta (g/16 g N). Broilereilla suoritetussa kokeessa vehnävalkuaistiivisteellä korvattiin soijajauhoa siten, että käyttömäärät olivat 0, 6, 12,5 ja 19 % rehusta joko ilman aminohappolisäyksiä (metioniini, lysiini) tai niillä täydennettynä.

Vehnävalkuainen hidasti merkitsevästi ($P < 0,01$) alle 3-viikkoisten broilereiden kasvua kaikilla käyttötasoilla 0-tasoon verrattuna. Sen sijaan ikävälillä 3–6 viikkoa lisäkasvussa ei ollut merkitsevää eroa 0 ja 6 %:n tasojen välillä, mutta suurimmat vehnävalkuaisen pitoisuudet hidastivat kasvua erittäin voimakkaasti ($P < 0,01$). Aminohappolisäys paransi tuntuvasti broilereiden kasvua ($P < 0,01$). Rehunkulutus laski viimeisellä jaksolla vehnävalkuaisen määrän lisääntyessä. Rehuhyötysuhde oli sama 0:n ja 6 %:n tasoilla, mutta muilla selvästi edellisiä heikompi.Tulosten mukaan vehnävalkuaistiivistettä tulisi mieluummin käyttää broilerkasvatuksen toisella jaksolla ja silloinkin vain noin 5 % rehusta.

ANNALES AGRICULTURAE FENNIAE, VOL. 22: 221–231 (1983)

Seria ANIMALIA DOMESTICA N. 66 – Sarja KOTIELÄIMET n:o 66

EFFECTS OF REGENT RAPESEED MEAL FED DURING THE REARING AND LAYING PERIOD ON THE PERFORMANCE OF CHICKENS

TUOMO KIISKINEN

KIISKINEN, T. 1983. **Effects of Regent rapeseed meal fed during the rearing and laying period on the performance of chickens.** Ann. Agric. Fenn. 22: 221–231. (Agric. Res. Centre, Inst. Anim. Husb., 31600 Jokioinen, Finland.)

White Leghorn chickens were fed three dietary levels of Regent low glucosinolate rapeseed meal (RSM) (0/0, 7,5/5 and 15/10 % in their starter and grower feed). During the subsequent laying period four levels of RSM (0, 5, 10 and 17 %) were used.
Inclusion of RSM in the rearing diets reduced by approximately 40 g ($P < 0,05$) the body weights of the pullets but did not significantly affect feed consumption or mortality. The use of RSM in the rearing diets had no significant effects on the mortality or performance of the hens, excluding egg weight ($P < 0,05$), during the subsequent laying period. Mortality and incidence of haemorhagic and injured livers increased considerably among hens fed 10 and 17 % RSM in their diet. The hen-housed production on the 17 % RSM level was considerably lower ($P < 0,05$) than on the other levels. The highest RSM concentration also reduced the daily egg output ($P < 0,05$) in comparison with the 0 and 5 % RSM levels.

Feed consumption and body weight gain of hens decreased when the RSM content increased in the diets, and the differences between the control and two highest RSM levels were significant ($P < 0,05$). No significant differences existed in feed efficiency.

Inclusion of RSM in the diets of hens and cocks did not adversely affect the reproductive performance. The RSM feeding had a clear goitrogenic effect during both the rearing and laying period and this effect could also have been confirmed in the progeny of the highest RSM level. The specific gravity of eggs produced on the RSM diets was significantly ($P < 0,05$) lower at the end of the production period than that produced on the control diet.

The results suggest that the dietary level of rapeseed meal extracted from low glucosinolate cultivars should be limited in long-term use.

Index words: rapeseed meal, chicken, hen, growth, egg production, mortality, reproduction, thyroid weight, liver lesions.

INTRODUCTION

As far as egg production is concerned, low glucosinolate rapeseed meals (LG-RSM) have satisfactorily provided the largest part or all of the supplementary protein of layers' diet. However, mortality has sometimes shown a tendency towards an increase when considerable amounts of LG-RSM have been included in the diets of laying hens (MARANGOS et al. 1974, VOGT and TORGES 1976, GRANDHI et al. 1977, SLINGER et al. 1978, THOMAS et al. 1978, HULAN and PROUDFOOT 1980 a, 1981, KIISKINEN 1983 a). The incidence of haemorrhagic and fatty liver syndrome has often been higher among the RSM fed hens than the control hens and the higher mortality of the former has been attributed to the liver lesions (JACKSON 1969, MARCH et al. 1975, 1978, LEESON et al. 1976, SMITH and CAMPBELL 1976, GRANDHI et al. 1977, PAPAS et al. 1979, HULAN and PROUDFOOT 1981).

The Brassica meals have not generally had any detrimental effects on fertility or hatchability of the domestic fowl (O'NEIL 1957, McGREGOR and BLAKELY 1964, ROBBLEE and CLANDININ 1967, SUMMERS et al. 1971, MARCH et al. 1972, LESLIE and SUMMERS 1975, PROUDFOOT et al. 1982). SUMMERS et al. (1971) and KUBOTA et al. (1972) found a decrease in hatchability when RSM was included in the diets of breeding hens. LIPINSKA (1978) reported increased mortality of embryos and decreased viability of newlyhatched chicks, and GAWECKI et al. (1972) ascertained a decreased weight of hatched chicks in the breeding groups which were fed RSM in their diet. It has been verified that abundant use of RSM results in hypertrophy of the thyroid gland of progeny, too (MARCH et al. 1972, GAWEKI et al. 1972, LESLIE and SUMMERS 1975, LIPINSKA 1978).

HULAN and PROUDFOOT (1980 a, b) investigated the effects of feeding LG-RSM to chickens during both the rearing and laying period. They found that the long-term use of RSM had no negative effects on egg production or feed efficiency, but switching the birds from a soybean meal (SBM) grower diet to a 15 % RSM layer diet resulted in a significant ($P < 0{,}05$) increase in mortality. The present study was designed to investigate the effects of feeding LG-RSM from Regent cultivar on the performance of chickens during the rearing and laying (breeding) period.

MATERIAL AND METHODS

Animals and housing

A total of 1620 WL chicks (strain SK 51) consisting of 1500 females and 120 males, were brooded and reared to 18 weeks of age in three-tier batteries, 20 birds per cage with an area of 1 m^2. Continuous lighting of 20 lux was used during the first week and 16 hours of 10 lux during the second week. For the remainder of the rearing period the duration was reduced to 8 hours and light intensity to 5 lux. The room temperature during the first two weeks was 33–34 °C and was reduced by 2–3 °C weekly and maintained at 17 °C during the period of 9–18 weeks.

At 18 weeks of age the birds were moved to a layers' house with three-tier batteries. Three hens were placed in each cage (700 cm^2/hen). The duration of lighting was increased by 20 minutes weekly to 16 hours, with an intensity of 10 lux. A room temperature of 17 °C was maintained. The laying period lasted eleven periods of 28 days. The cocks were also kept in three-tier batteries in a different room.

Diets and feeding

The rapeseed meal used was derived from the same lot of Regent meal tested in the author's earlier experiment on broiler chicks (KIISKINEN 1983 b). All diets contained meat and bone meal and single cell protein as domestic protein sources (Table 1). Three levels of RSM were used in the starter/grower diets (0/0, 7,5/5 and 15/10 %), and four levels in the layer diets (0, 5, 10 and 17 %). The rapeseed meal gradually replaced soybean meal in the starter diets. In the grower and layer diets RSM also replaced all fish meal on the highest level of RSM. All diets were supplemented with methionine. The diets were not quite isocaloric, although the grower diets were balanced using sand as bal'last and the layer diets with supplementary fat. The birds had free access to feed and water.

Experimental procedure

Each dietary treatment involved 500 female and 40

Table 1. Composition and calculated contents of the diets.

	Starters (0–6 weeks)			Growers (6–18 weeks)			Layers (cocks)			
RSM %	0	7,5	15	0	5	10	0	5	10	17
Fish meal	5	5	5	3	3	–	3	3	3	–
Meat and bone meal	3	3	3	3	3	3	3	3	3	3
Soybean meal	15	9,5	4	3,5	–	–	7	3,5	–	–
RSM (Regent)	0	7,5	15	0	5	10	0	5	10	17
Single cell protein[1)]	1	1	1	0,5	0,5	0,5	1	1	1	1
Wheat	15	15	15	–	–	–	–	–	–	–
Barley	33,8	31,8	29,8	50,6	49,6	47,6	53,8	53,8	53,8	53,8
Oats	20	20	20	30	30	30	24(30)	22(28)	20(26)	15,5 (21,5)
Grass meal	4	4	4	3	3	3	–	–	–	–
Rapeseed oil	1,3	1,3	1,3	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Animal fat	–	–	–	–	–	–	–	0,5	1,0	1,5
Limestone, ground	–	–	–	–	–	–	6,3 (0,3)	6,3 (0,3)	6,3 (0,3)	6,3 (0,3)
Dicalcium phosphate	1	1	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Sodium chloride	0,38	0,38	0,38	0,38	0,38	0,38	0,43	0,43	0,43	0,43
Vitamin premix[2)]	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
Mineral premix[3)]	0,3	0,3	0,3	0,3	0,3	0,3	0,25	0,25	0,25	0,25
D-methionine	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
Sand	–	–	–	4,5	4	3,5	–	–	–	–
Crude prot. %	20,6	20,5	20,4	14,8	14,9	14,5	15,9	15,8	15,8	15,6
ME MJ/kg	11,2	11,1	11,0	10,4	10,4	10,2	10,5	10,5	10,5	10,4
Methionine %	0,45	0,45	0,46	0,35	0,35	0,32	0,36	0,36	0,36	0,34
Lysine %	1,10	1,09	1,08	0,72	0,72	0,65	0,80	0,79	0,78	0,74

1) Pekilo and Silva products

2) Supplies per kilogram of diet; 15000 IU vitamin A, 1500 IU vitamin D_3, 20 mg vitamin E, 1 mg vitamin K, 3 mg riboflavin, 1,5 mg pyridoxine, 18 mg niacin, 15 µg vitamin B_{12}, 0,3 mg folic acid, 500 mg choline chloride, 1,5 mg Carophyll Red (10 %)

3) Supplies per kilogram of diet: 20 mg Fe, 45 mg Zn, 48 mg Mn, 4 mg Cu, 0,6 mg Co, 0,5 mg I, 0,1 mg Se.

male chicks, which were weighed individually at 6 and 18 weeks of age. Feed consumption was measured per tier, with four replicates per treatment. A record was kept of mortality and leg weakness. Twelve replicates of 30 hens were assigned to each of the four laying diets. The four replicates of each treatment in the rearing house were randomly distributed into each treatment of the laying (breeding) period. During the laying phase the study thus had a 3 × 4 factorial design.

The following characteristics were measured: egg production, feed consumption, percentage mortality, live weight (21 and 63 weeks), egg shell strength as measured by specific gravity, interior quality as measured by height of albumen and Haugh Unit (36, 51 and 64 weeks). An average of 85 hens per treatment were inseminated three times (37, 41 and 49 weeks) with sperm from the cocks of the corresponding treatment. Fertility and hatchability were recorded and dead embryos from the experimental hatchings were investigated for malformations at the National Veterinary Institute. The chicks were checked one week after hatching.

Thyroid glands and livers of 22 pullets and thyroid glands of 24 laying hens per treatment were removed and weighed at the end of the period. The glands of dead hens from each treatment and one-week-old chicks of the extreme groups (0 and 17 % RSM) were also weighed. Some of the dead birds were sent to the National Veterinary Institute.

The proximate analysis was performed for every lot of the experimental diets. Amino acids were determined with a gas chromatograph (Hewlet Packard 1570) for a common sample of each diet. Calcium was analysed with an atomic absorption spectrophotometer and phosphorus with a photometer after colour reaction with ammonium vanadate.

Data were subjected to analyses of variance and Tukey's test (Steel and Torrie 1960).

Table 2. The analysed contents of the diets.

	Starters			Growers			Layers			
RSM %	0	7,5	15	0	5	10	0	5	10	17
Proximate analysis (±SD)										
N	1	1	1	8	8	8	12	12	12	12
Dry matter %	87,8	88,0	88,1	87,3 ± 0,8	87,9 ± 0,7	88,1 ± 0,4	88,5 ± 0,4	88,5 ± 0,4	88,7 ± 0,5	88,7 ± 0,5
Crude protein %	20,6	20,3	20,1	13,8 ± 0,6	13,9 ± 0,5	13,7 ± 0,7	14,7 ± 0,8	14,9 ± 0,7	14,5 ± 0,8	14,7 ± 0,5
Ether extract %	4,7	5,3	6,0	3,7 ± 0,2	4,2 ± 0,2	4,5 ± 0,2	3,4 ± 0,1	4,3 ± 0,2	5,1 ± 0,4	5,8 ± 0,6
Crude fibre %	4,6	5,1	5,4	5,9 ± 0,3	6,3 ± 0,3	6,7 ± 0,3	5,4 ± 0,5	5,5 ± 0,6	5,8 ± 0,7	6,1 ± 0,6
Ash %	5,8	5,9	6,0	9,5 ± 4,8	9,0 ± 4,2	8,3 ± 3,4	9,2 ± 1,6	9,4 ± 1,4	9,1 ± 1,2	8,6 ± 1,5
Amino acids (% in diet)										
Methionine	0,33	0,31	0,30	0,22	0,17	0,22	0,22	0,18	0,20	0,24
Lysine	1,05	1,02	1,01	0,58	0,51	0,49	0,57	0,63	0,64	0,63
Arginine	1,29	1,22	1,25	0,80	0,77	0,75	0,57	0,52	0,64	0,63
Isoleucine	0,80	0,91	0,90	0,59	0,60	0,58	0,69	0,61	0,64	0,72
Threonine	0,78	0,85	0,82	0,54	0,54	0,55	0,65	0,63	0,61	0,65
Calcium %	0,90	0,91	0,95	0,73	0,78	0,72	2,76	2,59	2,57	2,50
Phosphorus %	0,88	0,93	0,99	0,67	0,72	0,72	0,65	0,67	0,68	0,69

RESULTS AND DISCUSSION

The data on crude protein analyses of the grower and layer diets were on average one percentage unit below the calculated values (Table 2). The analysed methionine concentrations were too low to be credible in comparison with the calculated contents and the performance of the birds. Methionine was clearly partly destroyed in the hydrolysis of the samples for gas chromatography.

Chickens of both sexes were lighter when fed the rapeseed meal diets than when fed the control diet, and the differences between the females were significant ($P < 0,05$) at both 6 and 18 weeks of age (Table 3). Naturally a decreased weight of WL pullets or cockerels of this magnitude is of no account, but retarded growth of Leghorn-type chickens has been reported only when 20 % LG-RSM has been included in their diet (Hulan and Proudfoot 1980 a, b). Apparently, in the present study the reduced growth rate of the chickens fed RSM was connected with the low lysine content of the diets and decreased supply of this amino acid to the birds fed RSM.

No significant differences were ascertained in feed consumption and mortality between the dietary treatments (Table 3). This confirms the results of Hulan and Proudfoot (1980 a), which provided evidence that LG-RSM can replace a major portion of SBM in rearing diets without adversely affecting mortality or feed consumption. The relative weight of the thyroid glands of the pullets increased nearly linearly ($P < 0,05$) when the content of RSM in the diet increased, whereas the liver weight was not affected (Table 3).

Mortality during the laying period was 2–3 times higher ($P < 0,05$) on the two highest RSM levels (10 and 17 % in the laying diet) (Table 4). Several other authors have also found an increase in mortality of this magnitude as a result of inclusion of 10–15 % LG-RSM in layers' diet although no statistical significance has been confirmed (Vogt and Torges 1976, Grandhi et al. 1977, Slinger et al. 1978, Hulan and Proudfoot 1980 a, 1981).

High mortality of the 10 and 17 % RSM levels was

Table 3. Body weight feed consumption, mortality, thyroid and liver weight of chickens (±SD)[1)].

RSM %	0/0	7,5/5	15/10
Females			
Body weight g (6 weeks)	559 ± 56[a]	550 ± 55[b]	536 ± 53[c]
Body weight g (18 weeks)	1434 ± 131[a]	1394 ± 124[b]	1396 ± 130[b]
Males			
Body weight g (6 weeks)	657 ± 59	633 ± 77	627 ± 71
Body weight g (18 weeks)	1902 ± 170	1864 ± 187	1880 ± 190
Comb. sexes			
Feed cons. kg/bird (0–6 weeks)	1,26 ± 0,06	1,26 ± 0,05	1,23 ± 0,05
Feed cons. kg/bird (6–18 weeks)	5,86 ± 0,32	5,82 ± 0,27	5,79 ± 0,37
Mortality % (0–6 weeks)	4,1 ± 1,9	5,0 ± 2,6	3,8 ± 1,7
Mortality % (6–18 weeks)	0,7 ± 0,5	1,0 ± 0,9	2,4 ± 3,2
Pullets			
Thyroid weight mg/100 g body wt. (N = 22)	11,0 ± 3,7[a]	15,1 ± 5,4[b]	21,5 ± 8,6[c]
Liver weight g/100 g body wt. (N = 22)	1,84 ± 0,24	1,78 ± 0,30	1,75 ± 0,28

[1)] SD = standard deviation

a – c Means with a different superscript letter within a row are significantly different ($P < 0,05$). If no letters are used the differences are non-significant.

Table 4. Mortality, thyroid weight (±SD) and incidence of haemorrhagic and injured livers as a response to the dietary treatment during the rearing and laying period[1].

	Rearing period			Laying period			
RSM %	0/0	7,5/5	15/10	0	5	10	17
Mortality %[2]	9,5 ± 5,7	9,7 ± 6,7	12,0 ± 8,4	5,9 ± 5,2^{a}	7,6 ± 4,8^{ab}	11,2 ± 5,2^{b}	16,9 ± 7,2^{c}
Thyroid weight mg/100 g body wt.							
killed hens (63 weeks)[2]	12,7 ± 6,5^{a}	15,3 ± 7,6^{a}	19,6 ± 8,3^{b}	9,9 ± 3,9^{a}	15,1 ± 7,1^{b}	18,2 ± 5,6^{bc}	20,3 ± 10,0^{c}
dead hens	14,5 ± 6,6^{a}	17,6 ± 9,0^{a}	22,9 ± 11,1^{b}	14,9 ± 7,3	17,5 ± 9,8	19,7 ± 10,3	19,8 ± 10,1
Number of haemorhagic and injured livers/ dead obducted hens	19/47	19/46	26/48	3/20	7/30	16/35	38/56

[1] SD = standard deviation
[2] Significant interaction (P 0,05) between the treatments of the periods.
a – c Means with a different superscript letter within a row of the period are significantly (P < 0,05) different. If no letters are used the differences are non-significant.

in agreement with the strongly increased incidence of haemorrhagic and injured livers. Grandhi et al. (1977) and Hulan and Proudfoot (1980 a) also found a high frequency of haemorrhagic livers among dead hens fed 10–20 % LG-RSM. At the end of the study, the thyroid weight of the hens fed RSM was 1,5–2 times higher (P < 0,05) than that of the control hens (Table 4). Enlargement of the gland of approximately same magnitude has been found when dietary levels of 10–20 % LG-RSM have been used during the laying period (Vogt and Torges 1976, Grandhi et al. 1977, March et al. 1978, Thomas et al. 1978, Kiiskinen 1983 a). The differences in thyroid weight between the treatments were relatively small among dead hens.

The use of RSM during the rearing period did not significantly affect mortality during the subsequent laying period (Table 4). This is in agreement with the observations of Hulan and Proudfoot (1980 a), which suggested that preconditioning the birds to rapeseed meal during the rearing period had no effect on subsequent mortality. Enlargement of the thyroid gland of hens occurred as a result of the use of RSM during the rearing period and this increase was significant (P < 0,05) on the highest RSM level.

No significant differences in development of sexual maturity of the hens were observed between the treatments during the rearing period when the age at 50 % laying is used as a measure (Table 5). As a whole the feeding regimen during the rearing period did not affect the subsequent production parameters, except egg

Table 5. Performance of the laying hens as a response to the dietary treatments during the rearing and laying period[1].

	Rearing period (0–18 weeks)			Laying period				
RSM %	0/0	7,5/5	15/10	0	5	10	17	SE
Age at 50 % laying days	184	183	185	–	–	–	–	0,56
Egg production								
kg/housed hen	12,32	12,32	11,95	12,66^{a}	12,62^{a}	12,16^{a}	11,35^{b}	0,114
% (hen-day)	72,2	72,9	71,7	73,2^{a}	73,5^{a}	72,0^{ab}	70,2^{b}	0,41
egg output g/hen/day	42,0	42,0	41,2	42,5^{a}	42,6^{a}	41,5^{ab}	40,4^{b}	0,25
Egg weight g	58,1^{a}	57,5^{b}	57,4^{b}	58,0	57,9	57,5	57,4	0,12
Feed intake g/hen/day	112,4	111,0	110,4	114,6^{a}	112,2^{ab}	110,2^{b}	108,0^{bc}	0,52
kg/kg eggs	2,74	2,69	2,74	2,76	2,68	2,70	2,74	0,14
Protein intake g/h/d	16,5	16,3	16,2	16,9^{a}	16,7^{a}	15,9^{b}	15,9^{b}	0,09
g/kg eggs	402	395	402	406	400	391	403	2,1
ME intake KJ/h/d	1176	1161	1155	1195^{a}	1178^{ab}	1158^{b}	1123^{c}	5,8
MJ/kg eggs	28,7	28,2	28,7	28,9	28,2	28,5	28,5	0,14
Final body weight g	2061^{a}	2007^{b}	2033^{c}	2063^{a}	2052^{ab}	2039^{b}	1982^{c}	7,8
Weight gain %	34,4	32,5	33,1	36,1^{a}	34,1^{ab}	31,5^{b}	31,6^{b}	0,15

[1] No significant interactions between the periods was ascertained
a – c see Table 4.
SE = standard error

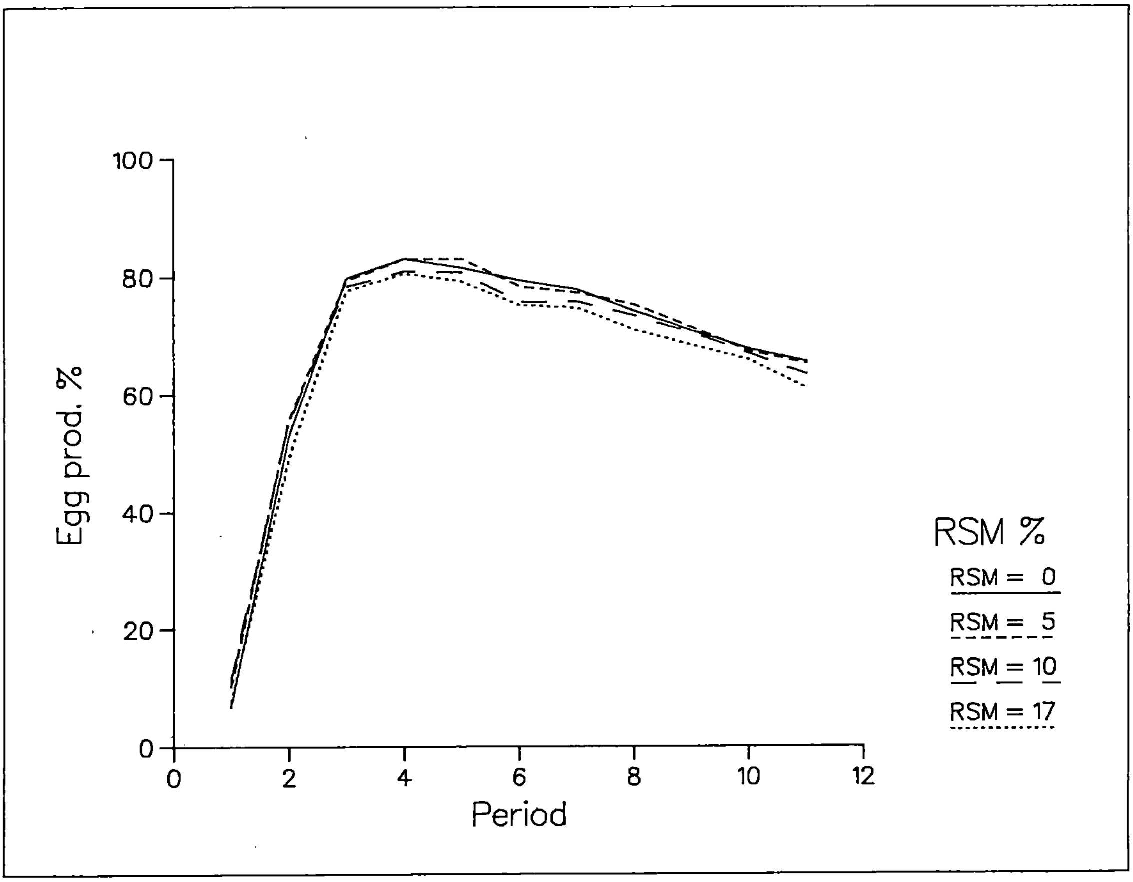

Figure 1. Percentage egg laying.

weight, which was 0,5–0,6 g lower (P < 0,05) in the RSM groups than in the control group. A similar tendency was also observed in the studies of Hulan and Proudfoot (1980 a, b). Apparently, decreased egg weight were associated with the reduced body size of the pullets fed RSM in both this study and the studies of Hulan and Proudfoot (1980 a, b).

Egg production expressed as percentage laying, egg output g/hen/day or kg/housed hen did not differ significantly between the treatments of 0, 5 and 10 % RSM in the layer diet (Table 5, Figure 1). All the above-mentioned parameters were significantly (P < 0,05) lower on the 17 % RSM level than on the control diet. It is worth nothing that on the two highest RSM levels the hen housed production was clearly lower than on the 0 and 5 % RSM levels, partly because of the high mortality of the former dietary regimens. The egg weight was decreased by an average of 0,5 g on the levels of 10 and 17 % RSM in the diet compared with the lower levels. This phenomenon has been quite common when LG-RSM has been used up to 10–20 % in layers' diet, although statistical significance has not always been ascertained (Vogt and Torges 1976, Grandhi et al. 1977, Robblee et al. 1978, Slinger et al. 1978, Hulan and Proudfoot 1980 a, b, Thomke et al. 1983). This is clearly connected with the body weight of the hens. Feed intake decreased when the content of RSM increased in the diet and the differences between the two highest RSM levels and the 0 % level were significant (P < 0,05; Table 5). Although decreased feed intake has been found in connection with the use of LG-RSM in layers' diet (Slinger et al. 1978), in the present study it might have been due to the higher fat content in the RSM diets than in the control diet (Tables 1 and 2). On the other hand the reduced final body weights and percentage weight gain on the 10 and 17 % diets compared with the control diet ($P < 0,05$) refer to decreased energy supply of the former groups, as the calculated values show ($P < 0,05$). The efficiency of feed conversion did not differ significantly between the treatments. No significant interactions were ascertained in the performance of hens between the treatments of the rearing and laying period.

The use of RSM did not significantly affect the height of albumen or Haugh Unit of the eggs (Table 6). This agrees with the results of earlier studies (Leslie and Summers 1972, Vogt and Stute 1974, Blair et al. 1975, Olomu et al. 1975, Thomas et al. 1978, Hulan and Proudfoot 1980 a, b, Kiiskinen 1983 a). The specific gravity of eggs at the end of the laying period was lower on the RSM diets than on the control diet ($P < 0,05$). This tendency was also found in the studies of Hulan and Proudfoot (1980 a, b), but according to them this was a result of the higher egg production of RSM groups in that phase. In the present study the possible reason for this phenomenon is the decreased calcium and increased phosphorus content of the RSM diets (Table 2).

Table 6. The results of egg quality tests$^{1)}$.

		Rearing period				Laying period				
RSM % in diet		0/0	7,5/5	15/10		0	5	10	17	SE
	N				N					
36 weeks										
Height of albumen	160	6,2	6,2	6,2	120	6,3	6,3	6,4	6,1	0,05
Haugh Unit	"	79,4	79,8	80,0	"	$80,2^{ab}$	$80,3^{ab}$	$80,8^{a}$	$78,5^{b}$	0,31
Spec. gravity	"	1,0832	1,0826	1,0838	"	1,0829	1,0839	1,0833	1,0827	0,00028
51 weeks										
Height of albumen	"	5,5	5,6	5,6	"	5,6	5,7	5,5	5,5	0,05
Haugh Unit	"	72,2	73,8	73,2	"	74,4	74,4	73,5	73,3	0,37
Spec. gravity	"	1,0820	1,0825	1,0816	"	$1,0826^{a}$	$1,0816^{b}$	$1,0828^{a}$	$1,0811^{b}$	0,00020
64 weeks										
Height of albumen	"	5,2	5,3	5,3	"	5,4	5,2	5,2	5,1	0,05
Haugh Unit	"	69,0	70,2	70,3	"	71,1	69,0	69,3	68,2	0,43
Spec. gravity	"	$1,0799^{a}$	$1,0812^{b}$	$1,0799^{a}$	"	$1,0820^{a}$	$1,0795^{b}$	$1,0800^{b}$	$1,0798^{b}$	0,00024

$^{1)}$ No significant interactions between the periods was ascertained
a – b See Table 4.

The inclusion of Regent RSM in the layer diets had no detrimental effects on fertility or hatchability (Table 7). The number of malformations among dead embryos was low and the average weight of the hatched chicks was equal in the groups. The body weight of one-week-old chicks hatched from the eggs produced on the 10 and 17 % RSM diets were slightly lower than those of the 0 and 5 % RSM groups but the differences were not significant. Slight hypertrophy of the thryroid glands of the progeny was ascertained ($P < 0,05$) on the 17 % LG-RSM level.

It is concluded that the Regent low-glucosinolate rapeseed meal can be used in the diets of chickens during both the rearing and the subsequent laying period. However, because of increased mortality and high incidence of liver lesions the content of LG-RSM of this type ought to be limited in long-term use to 5–10 % in the diet in order to avoid economic losses as a result of decreased hen-housed production.

Table 7. Mean results of the hatchings and performance of progeny during the first week.

RSM % in diet	0	5	10	17	SE	
Number of eggs incub.	584	656	621	576		
Fertility %	90,7	86,9	93,7	91,0	0,99	NS
Hatchability %	86,4	82,6	88,3	85,5	1,16	"
Number of malformations in dead embryos	1	1	2	–		
Mean body weight of day old chicks	40,9	40,9	40,9	40,6	0,28	"
Mean body weight of one week old chicks	67,5	67,5	65,0	64,1	1,14	"
Mortality of chicks %	1,1	1,1	1,2	2,4	0,19	"
Leg abnormalities %	3,1	4,4	4,3	4,4	0,33	"
Thyroid weight of one week chicks mg/100 g body wt. (±SD, N 40)	6,8 ± 3,0	–	–	8,3 ± 3,2		*

NS = non-significant
* $P < 0{,}05$

REFERENCES

Blair, R., Robblee, A. R., Dewar, W. A., Bolton, W. & Overfield, N. D. 1975. Influence of dietary rapeseed meals and selenium on egg production and egg tainting in laying hens. J. Sci. Food. Agric. 26: 311–318.

Gawecki, G., Godynicki, S., Lipinska, H., Ponikiewska, T., Torgowski, J. & Wiland, D. C. 1972. Wplyw poekstrakcyjnych śrut rzepakowych w dawkach dla matek na potomstwo. Rocz. Nauk. Rol. Ser. B, 94: 15–29.

Grandhi, R. R., Slinger, S. J. & Summers, J. D. 1977. Productive performance and liver lesions in two strains of laying hens receiving two rapeseed meals. Poult. Sci. 56: 1904–1908.

Hulan, H. W. & Proudfoot, F. G. 1980 a. The nutritional value of rapeseed meal for caged layers. Can. J. Anim. Sci. 60: 139–147.

– & Proudfoot, F. G. 1980 b. The nutritional value of rapeseed meal for layer genotypes housed in pens. Poult. Sci. 59: 585–593.

– & Proudfoot, F. G. 1981. Performance of laying hens fed diets containing soybean gums, rapeseed gums or rapeseed meals with and without gums. Can. J. Anim. Sci. 61: 1031–1040.

Jackson, N. 1969. Toxicity of rapeseed meal and its use as a protein supplement in the diet of two hybrid strains of caged laying birds. J. Sci. Food. Agric. 20: 734–740.

Kiiskinen, T. 1983 a. Use of Tower rapeseed fed separately and together with pea meal to replace fish and soybean meal in layers' diet at varying protein concentrations. Ann. Agric. Fenn. 22: 195–205.

– , 1983 b. The effect of diets supplemented with Regent rapeseed meal on performance of broiler chicks. Ann. Agric. Fenn. 22: 206–213.

Kubota, D., Hijikuro, S., Kubo, T., Matsushima, M., Noguchi, S., Imai, I., Ino, M., Hiranu, K. & Taie, S. 1972, (Nutritive value of rapeseed meal as a feedstuff for poultry). Jap. Poult. Sci. 9: 274–280. (Ref. Nutr. Abstr. and Rev. 43: Abstr. 6345).

Leeson, S., Summers, J. D. & Grandhi, R. Carcass characteristics and performance of laying birds fed rapeseed meal. Can. J. Anim. Sci. 56: 551–558.

Leslie, A. J. & Summers, J. D. 1975. Influence of rapeseed products on reproductive performance of the hen and subsequent chick growth. Poult. Sci. 54: 916–917.

Lipinska, H. 1978. Rapeseed oil meals in feeding poultry. II Rapeseed meals from continuous and discontinuous extractions. Rocz. Nauk. Zoot. 10: 17–67.

Marangos, A., Hill; R., Laws, B. M. & Muschamp, D. 1974. The influence of three rapeseed meals and a mustard seed meal on egg and broiler production. Br. Poult. Sci. 15: 405–414.

March, B. E., Biely, J. & Soong, R. 1972. Rapeseed meal in the chicken breeder diet. Effects on production, mortality, hatchability and progeny. Poult. Sci. 51: 1581–1596.

– , Biely, J. & Soong, R. 1975. The effects of rapeseed meal fed during the growing and/or laying periods on mortality and egg production in chickens. Poult. Sci. 54: 1875–1882.

– , Bragg, D. B. & Soong, R. 1978. Low erucic acid, low glucosinolate rapeseed meal with and without added gums in the layer diet. Poult. Sci. 57: 1599–1604.

McGregor, H. I. & Blakely, R. M. 1964. Rapeseed oil meal as a supplement to a turkey breeder ration. Poult. Sci. 43: 189–192.

Olomu, J. M., Robblee, A. R., Clandinin, D. R. & Hardin, R. T. 1975. Effects of Span rapeseed meal on productive performance, egg quality, composition of liver and hearts and incidence of "fatty livers" in laying hens. Can. J. Anim. Sci. 55:

71–75.

O'NEIL, J. B. 1957. Rapeseed oil meal as a vegetable protein supplement in the diet of laying and breeding hens. Poult. Sci. 36: 1146 (Abstr.).

PAPAS, A., CAMPBELL, L. D., CANSFIELD, P. E. & INGALLS, J. R. 1979. The effect of glucosinolates on egg iodine and thyroid status of poultry. Can. J. Anim. Sci. 59: 119–131.

PROUDFOOT, F. G., HULAN, H. W. & MCRAE, K. B. 1982. The effect of diets supplemented with Tower and/or Candle rapeseed meals on performance of meat chicken breeders. Can. J. Anim. Sci. 62: 239–247.

ROBBLEE, A. R. & CLANDININ, D. R. 1967. Rapeseed meal in rations for breeder turkeys. Can. J. Anim. 47: 127–130.

— , CLANDININ, D. R., SLINGER, S. J. & SUMMERS, J. D. 1978. Rapeseed meal for poultry. Rapeseed Assoc. of Canada Publ. No 51: 12–17.

SLINGER, S. J., SUMMERS, J. D. & LEESON, S. 1978. Utilization of meal from a new rapeseed variety *Brassica campestris* cv. Candle in layer diets. Can. J. Anim. Sci. 58: 593–596.

SMITH, T. K. & CAMPBELL, L. D. 1976. Rapeseed meal glucosinolates; metabolism and effect of performance in laying hens. Poult. Sci. 55: 861–867.

STEEL, R. D. & TORRIE, J. H. 1960. Principles and Procedures of Statistics. 481 p. New York.

SUMMERS, J. D., PEPPER, W. F. & WOOD, A. S. 1971. The value of rapeseed meal in broiler breeder diets. Poult. Sci. 50: 1387–1391.

THOMAS, D., ROBBLEE, A. R. & CLANDININ, D. R. 1978. Effects of low and high glucosinolate rapeseed meals on productive performance, egg quality, composition of liver and incidence of haemorrhagic liver syndrome in laying birds. Br. Poult. Sci. 19: 449–454.

THOMKE, J., ELWINGER, K., RUNDGREN, M. & AHLSTRÖM, B. 1983. Rapeseed meal of Swedish low-glucosinolate type fed to broiler chickens, laying hens and growing-finishing pigs. Acta Agr. Scand. XXXIII: 75–96.

VOGT, H. & STUTE, K. 1974. Führt eine Senkung des Vinyl-Oxazolidinethion-Gehaltes zu einer Verbesserung des Futterwertes von Rapsextraktionsschrot im Geflügelfutter? Arch. Geflügelk. 38: 127–138.

— & TORGES, H-G. 1976. Rapsextractionsschrot aus einer erucasäure- und glucosinolatarmen Sommerrapssorte im Legehennenfutter. Arch. Geflügelk. 40: 225–231.

Manuscript received April 1983

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SELOSTUS

Kasvatuskauden ja/tai munintakauden rehussa käytetyn rapsijauhon (Regent) vaikutuksesta eläinten tuotantoon ja terveyteen.

TUOMO KIISKINEN

Maatalouden tutkimuskeskus

Rapsijauho oli uutettu Regent kaksinollalajikkeesta sisältäen kuitenkin verraten runsaasti öljyä (8 %). Käyttömäärät olivat starttirehussa (0–6 vk) 0, 7,5 ja 15, kasvatusrehussa (6–18 vk) 0, 5 ja 10 ja munitus (siitos-) kauden rehussa 0, 5, 10 ja 17 %. Kasvatus- ja munitusrehussa korkein rapsimäärä korvasi kalajauhon ja soijajauhon kokonaan. Kasvatuskauden lopussa kunkin ryhmän kanat ja kukot jaettiin munituskauden ryhmien kesken.

Rapsijauhon käyttö alensi nuorikoiden painoa n. 40 g:lla ($P < 0,05$), mutta rehunkulutukseen ja kuolleisuuteen sillä ei ollut merkitsevää vaikutusta. Rapsijauhon käyttö kasvatuskaudella ei vaikuttanut merkitsevästi munintakauden kuolleisuuteen ja tuotantoon. Munanpaino kylläkin aleni merkitsevästi ($P < 0,05$) ilmeisesti kanojen kevyemmän painon vuoksi.

Kuolleisuus lisääntyi huomattavasti ($P < 0,05$), kun rapsijauhoa käytettiin munintakaudella 10 ja 17 %. Näiden ryhmien kuolleissa eläimissä todettiin myös runsaasti revenneitä ja verisiä maksoja.

Runsas kuolleisuus aiheutti em. ryhmissä tuotannonlaskua, ja munamäärä (kg) alkanutta kanaa kohden oli 17 %:n rapsijauhomäärällä muita merkitsevästi pienempi ($P < 0,05$). Myös päivittäinen tuotanto (%, g) oli tällä tasolla 0 ja 5 %:n tasoja merkitsevästi heikompi ($P < 0,05$).

Kanojen rehunkulutus ja painonlisäys vähenivät rapsijauhomäärän lisääntyessä munituskauden rehussa. Kahden suurimman rapsijauhotason ja 0-tason väliset erot olivat merkitseviä ($P < 0,05$). Rehuhyötysuhteessa ei merkitseviä eroja todettu.

Rapsijauho ei vaikuttanut hedelmällisyyteen eikä hauduntatulokseen. Sillä oli selvä kilpirauhasen painoa lisäävä vaikutus sekä kasvatuskauden että munintakauden aikana. Suurimmalla käyttömäärällä vaikutus todettiin myös jälkeläisissä.

Tulosten mukaan myös vähän glukosinolaatteja sisältävän rapsijauhon määrää tulisi tajoittaa rehussa, jos käyttöaika on pitkä.

ANNALES AGRICULTURAE FENNIAE, VOL. 22: 232–239 (1983)

Seria AGRICULTURA N. 68 – Sarja PELTOVILJELY n:o 68

COMPETITION BETWEEN BARLEY AND ANNUAL WEEDS AT DIFFERENT SOWING DENSITIES

LEILA-RIITTA ERVIÖ

ERVIÖ, L-R. 1983. **Competition between barley and annual weeds.** Ann. Agric. Fenn. 22: 232–239. (Agric. Res. Centre, Inst. Pl. Husb., SF-31600 Jokioinen, Finland.)

In different growth densities the vegetative yield of barley was increased in stands up to a density of 550 plants/m². Correspondingly, the number of stems and the weight per plant were reduced. The grain yield was raised most by increasing the growth density from 100 to 200 and 400 plants/m².

Competition with barley markedly diminished the number and weight of weeds up to a growth density of 200 barley plants/m².

Treatment with the herbicide Actril 4, containing dichlorprop 274 g, MCPA 119 g, ioxynil 54 g and bromoxynil 36 g/l, increased both the vegetative yield and grain yield of barley in all densities. Herbicide treatment had a 95 % control effect even in the sparsest barley stand and any subsequent increase in density had no significant effect.

The density of weeds at which it was profitable to start chemical control was 67 plants/m². Herbicide treatment proved to be a more effective and economical means of control than growth density despite the good competitive capacity of barley.

Index words: competition, barley, grain yield, vegetative yield, stand density, weed number, weed weight, *Chenopodium album, Galeopsis* spp., herbicide treatment, dichlorprop, MCPA, ioxynil, bromoxynil, financial return.

INTRODUCTION

Weed control is always based on cultivation methods that enable the competitiveness of cultivated plants to be improved. A suitable growing density is especially important for creating favourable conditions for cultivated plants. The effect of density on the competitiveness between cultivated plants and weeds has been discussed in a number of investigations (e.g. SUOMELA and PAATELA 1962, WILLIAMS 1964, ERVIÖ 1972, 1977, HÅKANSSON 1979).

The present investigation concerns the Finnish part of a joint project carried out concurrently in all Nordic countries. The purpose of the investigation was to find out whether, by increasing sowing density, the competitive capacity of barley against weeds could be so improved that the control of weeds would be comparable with that by herbicide treatment.

The investigation in Finland was conducted in 1977–79 at the Institute of Plant Husbandry of the Agriucultural Research Centre.

MATERIAL AND METHODS

The effect of seeding rate on the competitiveness of two-rowed Ingrid barley was studied by field trials conducted on a stand treated with herbicide and on an untreated one. A split plot design with four replicates was used. Dressing with 90 kg/ha N, 40 kg/ha P and 74 kg/ha K was applied to the soil, which was sandy clay. Seeding rates were 0, 100, 300, 500, 750, 1000 and 1500 germinating seeds per sq. m. The sowing date was May 13 or 15. The plots were harvested on September 20, 1977–78 and on August 29, 1979.

At the 3–4 leaf stage of barley, half of the main plot number were treated with Actril 4, a herbicide containing dichlorprop 274 g, MCPA 119 g, ioxynil 54 g and bromoxynil 36 g/l.

Weeds were counted and harvested from 2 × 0,5 m^2 sample areas per plot in mid-July, when the weeds were full grown but not yet producing seeds. A barley sample was taken from the same areas. The weights of barley and weeds were determined by species and the number of barley stems and weeds were counted. The weights of each plant were calculated from these figures. The significance of the results was tested by stepwise regression analysis and analysis of variance.

Weather in the growing seasons 1977–79

May was warm in all three years. The early part of the growing season in 1977 was cooler than normal (Table 1) and precipitation varied considerably from month to month. Night frost occurred in early June. Summer 1978 was exceptionally dry until August and there were few weeds in early summer. The 1979 growing season was generally favourable for growth. Early summer in particular was very warm. Weeds were abundant and grew luxuriantly.

Table 1. Variation from the mean monthly values of temperature and precipitation during the growing seasons in Tikkurila 1977–1979.

Month	Average temperature °C			Precipitation mm		
	Variation from the mean values			Variation from the mean values		
	1977	1978	1079	1977	1978	1979
May	0,3	1,2	1,4	−15	−35	−13
June	−0,1	0,4	1,7	± 0	− 4	− 3
July	−2,4	−1,4	−2,1	+52	− 8	+20
August	−1,0	−1,7	0,7	−45	+52	−13
September	−2,4	−1,6	−0,6	+ 9	+37	+ 8

RESULTS

The number of weeds varied each year, being lowest in 1978 and most abundant in 1979. The dominant weeds in the fields were the usual weed species in Finland: *Chenopodium album, Galeopsis* spp., *Polygonum* spp., *Stellaria media* and *Viola arvensis.*

Sowing density

Length measurements performed at the spiking stage showed that the barley in the two areas least densely seeded was shorter than that in other stands. The rate of lodging in stands varied from year to year, but it was never intense and nor was it affected by the density of the stand.

The number of shoots. The emerged barley plants were counted at the end of May. Their numbers were as follows.

Sown plants/m^2	Emerged plants/m^2	%
100	85	85
300	214	71
500	373	75
750	552	74
1000	688	69
1500	973	65

The results show that the desired density of growth was not achieved, but that the denser the stand the greater was the thinning caused by intra-specific competition during germination and sprouting. The actual growth densities, approximated to 100, 200, 400, 550, 700 and 1000 plants/m^2, are therefore used in the presentation of results.

Table 2. Vegetative yield of barley in different stand densities.

Plants/m^2	Vegetative mass kg/ha[1)]		Percentage of barley in total vegetative mass	
	Untreated	Treated	Untreated	Treated
100	3260^a	4200^a	77	99
200	4810^b	5430^b	93	100
400	5620^c	5780^{bc}	95	99
550	6280^d	6630^d	98	100
700	5940^{cd}	6140^{cd}	97	100
1000	6050^{cd}	6690^d	98	100

[1)] Figures with the same index letter in the same column are not significantly different at the level of P = 0,05.

Vegetative yield of barley. The growth density affected the vegetative yield of barley in such a way that the quantity of straw produced per unit of surface area was increased in untreated stands and in those treated with herbicide up to a growth density of 550 plants/m^2 (Table 2). Likewise the number of stems per plant and the weight per plant were reduced (Table 3). The curve that best illustrated the change was parabolic (Table 4).

Table 3. The number and weight/plant of barley stems in different stand densities.

Plants/m^2	Stem number/plant		Stem weight g/plant	
	Untreated	Treated	Untreated	Treated
100	5	6	3,8	4,9
200	3	4	2,2	2,5
400	2	2	1,5	1,5
550	1	2	1,1	1,2
700	1	1	0,9	0,9
1000	1	1	0,6	0,7

Grain yield. When the sowing density of barley was increased, the grain yield changed differently from the vegetative plant mass. By increasing the growth density from 100 to 200 plants/m^2, the grain yield was raised by 820 kg/ha (Table 5). A similar yield was obtained from the stand of 400 plants/m^2. In areas more densely sown the increase in yield appeared to be reduced, though it did not differ statistically significantly from the greatest increase in yield.

The number and weight of weeds. The average number of weeds growing on the unsown plots was

Table 4. Equations illustrating the change in stem number/plant and stem weight/plant in increasing stand density (plants/m^2) of barley.

Variable	Equation	F-value	d.f.	Multiple correlation coefficient
Stem number				
untreated	$y = 5,527 - 0,740\ x + 0,030\ x^2$	15,89***	1, 31	0,72
treated	$y = 5,818 - 0,810\ x + 0,034\ x^2$	32,92***	1, 31	0,84
Stem weight				
untreated	$y = 3,903 - 0,536\ x + 0,021\ x^2$	12,17***	1, 31	0,71
treated	$y = 4,699 - 0,729\ x + 0,031\ x^2$	20,03***	1, 31	0,75

Table 5. Grain yield of barley in different stand densities.

Plants/m²	Grain yield[1)] kg/ha	Yield increase kg/ha
100	3240[a]	–
200	4060[b]	820
400	4060[b]	820
550	3920[b]	680
700	3930[b]	690
1000	3830[b]	590

[1)] See explanation in Table 2.

101 per m². They produced 1430 kg of air-dry plant mass/ha. Competition with barley in the stand markedly diminished the number of weeds and particularly their weight up to a growth density of 200 barley plants (Fig. 1). The weight of the weeds did not differ significantly in barley stands denser than that. Random variation was noted in the number of weeds in the dense stands.

Several different mathematical curves were calculated on the basis of the material to depict the change in the number and weight of weeds as a function of sowing density. The F-value, which tended to remain low, and the multiple correlation coefficient, however, indicated that they did not illustrate the trends in the material of this study particularly well.

Weed species. The most abundant weed species were *Chenopodium album* and *Galeopsis* spp. In the unsprayed pure weed stand the number of *C. album* individuals was 19 per m² and of *Galeopsis* spp. 22 per m². The air-dry yield of *C. album* per ha was then 1036 kg and of *Galeopsis* spp. 847 kg.

Competition with barley in the stands reduced the weight of the above species more clearly than their number. The increase in growth density brought about a change in weight that was sharp initially but levelled off, starting from the growth density of 200 barley plants (Figs. 2 and 3). Even in the sparsest barley the air-dry yield of *Galeopsis* spp. was only 25–30 % of the mass produced in the unsprayed weed stand. The corresponding yield of *C. album* was 34 %. Consequently the competition from barley in the stand notably restricted the growth of both weed species.

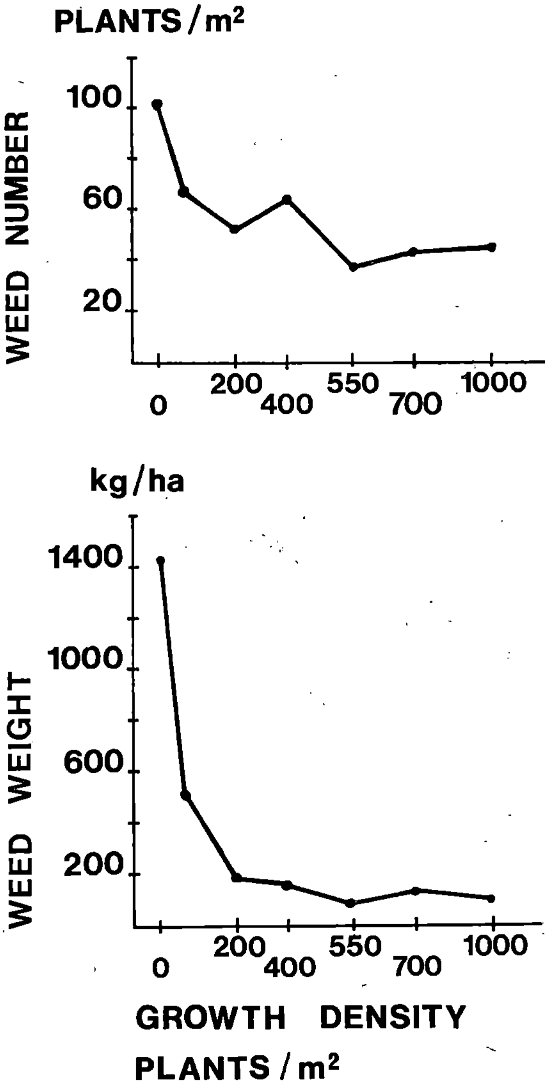

Fig. 1. Effect of barley density on the number and yield of weeds.

Herbicide treatment

Barley. Treatment with herbicide increased both the vegetative yield and the grain yield of barley in all densities (Table 2, Fig. 4). The increase in yield was greatest in the sparsest barley stand, in which the vegetative yield was augmented by 29 % and the grain yield by 14 % as a result of herbicide treatment.

The average grain yield of barley in unsprayed stands was 3710 kg/ha and in stands treated with

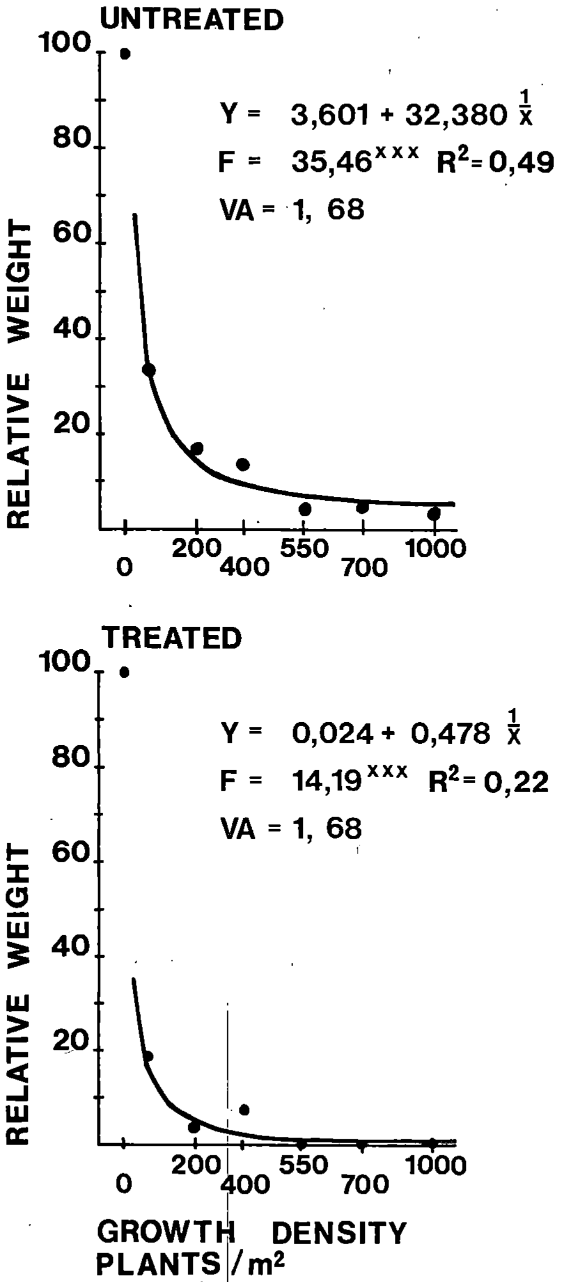

Fig. 2. Effect of barley density on the yield of *Chenopodium album*.

herbicides 3970 kg/ha. The treatment therefore produced a statistically significant increase of 7 % in grain yield.

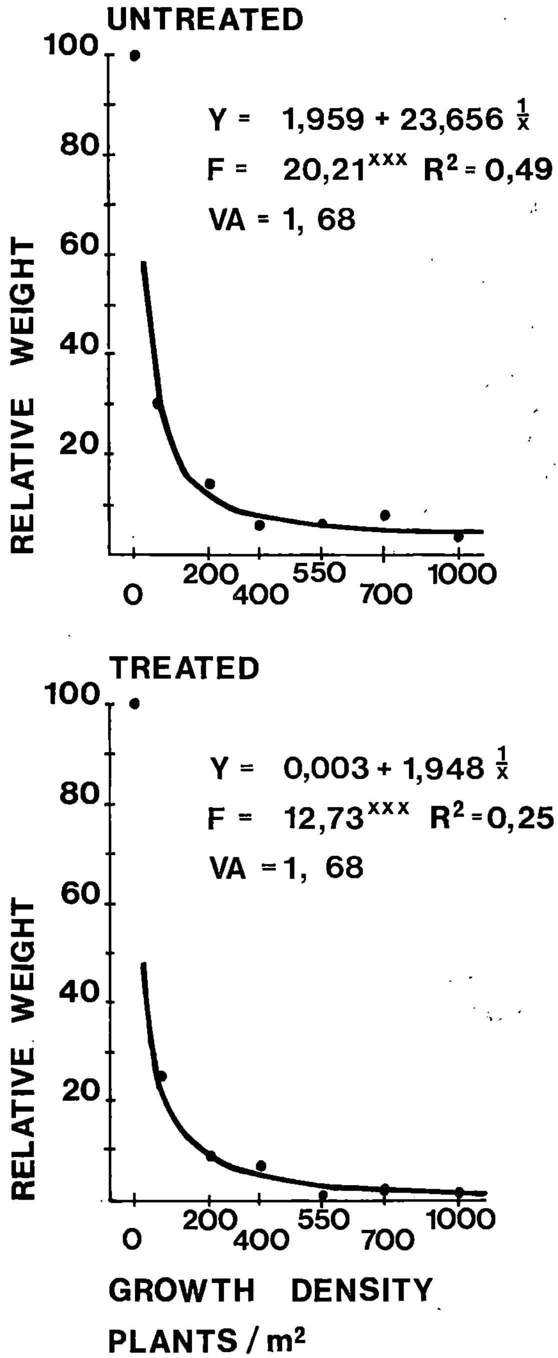

Fig. 3. Effect of barley density on the yield of *Galeopsis* spp.

The effect of herbicides on weeds. Herbicide treatment in stands of weeds alone reduced the weight

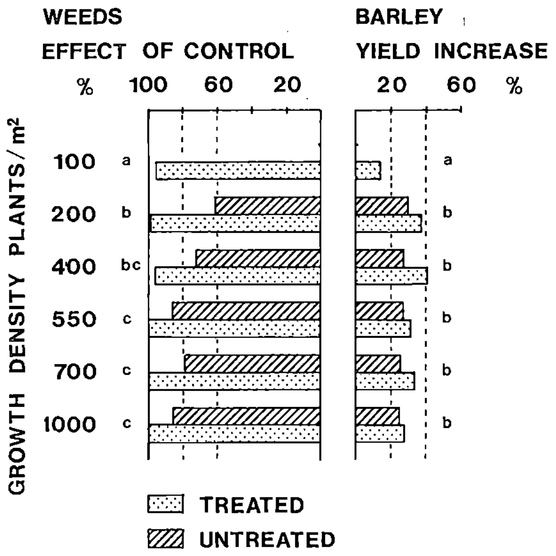

Fig. 4. Effect of barley density and herbicide treatment on weeds and on the grain yield. Weed control effect and the increase in barley yield in the sparsest untreated stand = 0. The results concerning the effect of density marked with the same letter are not significantly different at the level of P = 0,05.

of the weeds by 83 %. The greatest weed control achieved in unsprayed barley by increasing the growth density was 79–85 % in areas with 550 or more plants/m^2 (Fig. 4). The reduction in weed weight at densities of 200 and 400 barley plants/m^2 was 62–72 %. Herbicide treatment had a 95 % effect, even in the sparsest barley stand, and any subsequent increase in density had no significant effect. The reduction in average weed weight with herbicide treatment was 88 % (Table 6).

Herbicide treatment reduced the number of *C. album* by 95 % and their weight by 98 % (Table 6). The corresponding results for *Galeopsis* spp. were 60 % for number and 92 % for weight.

Table 6. Effect of herbicide treatment on the average number and yield of weeds.

Species		Number/m^2	Yield kg/ha
All weeds	untreated	91^b	650^b
	treated	25^a	77^a
C. album	untreated	21	294
	treated	1	5
Galeopsis spp.	untreated	10	203
	treated	4	17

Costs of weed control

The economic profitability of the control effects of growth density and chemical weed control were compared at the 1980 price level. Seeds of malting barley then cost Fmk 1,14/kg and in the autumn the producer received Fmk 1,30/kg for his yield. The herbicide used in the present investigation, Actril 4, cost Fmk 76 per ha at a dosage rate of 3 l/ha.

The financial return from the crop rose only up to the growth density of 200 barley plants (Table 7). Since the yield ceased to improve in stands of greater density, the spiralling costs of seeds reduced the financial return. This shows that it is not worth using a greater sowing rate than usual for the control of weeds. Furthermore, the control effect of sowing density alone and the ensuing financial result was poorer than that due to chemical control in all densities of barley, despite the cost of spraying. The density of weeds at which it was profitable to start chemical control in the present study was the smallest number of weeds that occurred in the untreated stand, that is 67 plants/m^2.

Table 7. Financial return from the crop when the costs of seeding and herbicide treatment are reduced.

Plants/m^2	Value of the yield mk/ha Untreated	Treated	Difference between treatments
100	3870	4350	+ 480
200	4940	5190	+ 250
400	4730	5160	+ 430
550	4560	4710	+ 150
700	4400	4610	+ 210
1000	4060	4120	+ 60

DISCUSSION

The competitiveness of plants in many investigations has been described by various coefficients (e.g. de WIT 1960, LAMPETER 1959–60) or by changes in the number, size and yield of competing species (WILLIAMS 1964, ERVIÖ 1971, 1977, SCAGG and McKELVIE 1976). In the present investigation the competitive capacity of barley was measured by the size of the yield and its proportion in the yield of mixed stands of barley and weeds (Tables 2, 5, Fig. 4). Since the subject of the investigation was a natural weed stand, no coefficients that describe competition could be used because they require specially sown pure stands and mixed stands.

Competition can cause natural intra-specific thinning in a stand. This is obviously what happened to barley in the present investigation, because compared with the seeding rate, relatively fewer shoots grew in the dense stands than in the sparse ones (p. 234).

The trend in the yield of barley with increased density (Tables 2, 5, Fig. 4) was as described in a number of previous investigations (e.g. ERVIÖ 1972, HÅKANSSON 1975, 1979). These studies show that the crop increases to a certain density after which the increase slows down and finally ceases altogether. In the present investigation the smallest sowing densities were, however, so close to the optimal density of a stand that the stage at which the yield was enhanced as density increased was very short. The number of stems of barley and their individual weights changed as one would expect in competition (Tables 3 and 4).

The competitive capacity of Ingrid barley, which was already good in the sparse stand, was improved by increasing the growth density; the proportion of barley in the whole yield of the stands rose concomitantly with density (Table 2). The unsprayed barley stand of 200 plants/m^2, which was more sparse than normal, reduced the yield of weeds to 180 kg per hectare. The control was thus 60 % effective. This can be regarded as satisfactory even though, when using herbicides, the aim is a reduction of at least 70 %. This was achieved without herbicide treatment in the stand of 400 barley plants, the yield of weeds then being 270 kg/ha. This is considerably less than the average weights noted in fields of spring crops in Finland. Various investigations show these to be 740 kg/ha (SUOMELA and PAATELA 1962), 1000 kg/ha (MUKULA 1974) and 1590 kg/ha (ERVIÖ 1972). In sprayed stands, herbicide treatment destroyed weeds, even in sparse barley, so successfully that the effect of the competitive capacity of barley could not be established (Fig. 4).

In the present investigation herbicide treatment proved to be a more effective and economical means of control than growth density despite the good competitiveness of barley (Table 7).

REFERENCES

ERVIÖ, L-R. 1971. The effect of intra-specific competition on the development of *Chenopodium album*. L. Weed Res. 11: 124–134.

– 1972. Growth of weeds in cereal populations. Maatal.tiet. Aikak. 44: 19–28.

– 1977. The effect of sowing density and mecoprop treatment on competition between winter wheat and *Tripleurospermum inodorum* (L.) Schultz BIP. Ann. Agric. Fenn. 16: 110–116.

HOFER, H. 1970. Über die Zusammenhänge zwischen der Düngung und der Konkurrenzfähigkeit ausgewählter Naturwiesenpflanze. Diss. 4500: 1–70. Zürich.

HÅKANSSON, S. 1975. Grundläggande växtodlingsfrågor I. Inflytande av utsädesmängden och utsädets horisontella fördelning på utveckling- och production i kortvariga växtbestånd. Rapp. och Avhandl. 33. 192 p. Uppsala.

– 1979. Grundläggande växtodlingsfrågor II. Faktorer av betydelse för plantetablering, konkurrens och production i åkerns växtbestånd. Sver. Lantbr.univ. Rapp. 72. 88 p. Uppsala.

MUKULA, J. 1974. Weed competition in spring cereal fields in Finland. Forskn. og Förs. Landbr. 25: 585–592.

SCRAGG, E, B. & McKELVIE, A. D. 1976. The effect of certain weeds on the grain yield of spring barley. Ann. Appl. Biol. 83: 335–338.

SUOMELA, H. & PAATELA, J. 1962. The influence of irrigation, fertil-

izing and MCPA on the competition between spring cerals and weeds. Weed Res. 2: 90–99.
Williams, J. T. 1964. A study of the competitive ability of *Chenopodium album*. Weed Res. 4: 283–295.
Wit, C. T. de 1960. On competition. Versl. Landbouwk. Onderz. 66: 1–82.

Manuscript received June 1983

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SELOSTUS

Kylvötiheyden vaikutus ohran ja rikkakasvien kilpailuun

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Maatalouden tutkimuskeskus

Tässä julkaisussa on esitetty Suomen osuus yhteispohjoismaisesta tutkimuksesta, joka oli käynnissä kaikissa Pohjoismaissa vuosina 1977–79. Tavoitteena oli selvittää, voidaanko ohran kylvötiheyttä lisäämällä parantaa sen kilpailukykyä rikkakasveja vastaan siinä määrin, että torjuntatulos korvaisi herbisidikäsittelyn.

Ohran kylvötiheydet olivat 0, 100, 300, 500, 750, 1000 ja 1500 itävää siementä/m^2. Siementen itämisen ja orastumisen aikana kasvusto harveni ilmeisesti lajinsisäisen kilpailun vuoksi sitä enemmän, mitä tiheämpi kasvusto oli. Todelliset kasvutiheydet olivat siten oraslaskennan mukaan 100, 200, 400, 550, 700 ja 1000 kpl/m^2. Kasvutiheyden lisääntyessä ohran korsimassa/pinta-alayksikkö suureni sekä herbisidillä käsitellyissä että käsittelemättömissä kasvustoissa tiheyteen 550 kpl/m^2 saakka. Jyväsato kasvoi 200–400 yksilön tiheyteen saakka.

Ohrattomilla koeruuduilla rikkakasvit tuottivat ilmakuivaa kasvimassaa 1430 kg/ha. Ohran kilpailu kasvustossa vähensi rikkakasvien määrää ja satoa jyrkästi 200 ohrayksilön tiheyteen saakka. Jauhosavikka ja pillikkeet olivat rikkakasveista runsaimpia.

Käsittely diklorproppia 274 g, MCPA:ta 119 g, ioksiniilia 54 g ja bromoksiniilia 36 g/l sisältävällä herbisidillä lisäsi sekä ohran korsimassaa että jyväsatoa kaikissa kylvöksissä. Sadonlisäys oli suurin harvimmassa ohrakasvustossa.

Kasvutiheyden lisäämisellä saavutettu rikkakasvien torjuntateho ruiskuttamattomassa ohrassa oli suurimmillaan 79–85 % 550 yksilön ja sitä tiheämmissä kasvustoissa. Herbisidikäsittelyllä saatiin 95-prosenttinen rikkakasviteho jo harvimmassa ohrakasvustossa eikä tiheyden lisäämisellä sen jälkeen enää ollut merkittävää vaikutusta.

Tiheän kasvuston aikaansaamiseksi tarvittu suuri siemenmäärä vähensi sadon taloudellista tuottoa. Ainakaan normaalia suurempaa kylvömäärää ei kannata käyttää rikkakasvien torjumiseksi. Kasvuston tiheyden torjuntavaikutus ja samalla myös taloudellinen tulos jäivät kaikissa ohran tiheyksissä kemiallista torjuntaa heikommiksi.

ANNALES AGRICULTURAE FENNIAE, VOL. 22: 240–244 (1983)

Seria AGROGEOLOGIA ET – CHIMICA N. 122 – Sarja MAA JA LANNOITUS n:o 122

EFFICIENCY OF AQUA REGIA IN EXTRACTING Cd, Cr, Hg, Ni AND Pb FROM SOILS OF DIFFERENT ORIGINS

NABIL H. BAGHDADY and JOUKO SIPPOLA

BAGHDADY, N. H. and SIPPOLA, J. 1983. **Efficiency of aqua regia in extracting Cd, Cr, Hg, Ni and Pb from soils of different origins.** Ann. Agr. Fenn. 22: 240–244. (Agric. Res. Centre, Inst. Soil. Sci., SF-31600 Jokioinen, Finland.)

As an average more than 90 % of soil total Cd and Ni was extracted by aqua regia. It was less effective in extracting Cr and Pb, the recovery being 60–70 % of the total content. Cadmium and lead were extracted almost completely from soils treated with sludge or sampled close to a lead smelter, showing that amounts extractable with aqua regia indicate pollution more sensitively than total amounts.

Total contents of Cd, Cr, Ni and Pb determined using the $HF-HNO_3-HClO_4$ method were in the ranges 0,05–0,93, 6–150, 4–75 and 14–48 mg/kg respectively. The respective amounts extractable with aqua regia were in the ranges 0,05–1,02, 6–120, 3–74 and 4–37 mg/kg. It was possible to determine mercury only in the aqua regia extracts and contents ranged from 0,015 to 0,15 mg/kg.

Index words: Total Cd, Cr, Hg, Ni, Pb, aqua regia, $HF-HNO_3-HClO_4$, Egyptian, Finnish and German soils.

INTRODUCTION

In recent years the heavy metals and their accumulation in soils have become an object of ever increasing interest. Metal pollution of soils is brought about by waste disposal on land and general industrialization, etc. Prolonged use of pesticides and sewage sludges containing heavy metals has led to the accumulation of Cd, Ni, Pb, As and Cu in agricultural soils (FRANK et al. 1976).

In many respects a knowledge of the total reserves of heavy metals in soil and of the factors affecting them is of great importance. As shown by MITCHELL (1955), the natural level of trace elements in mineral soils are primarily dependent on the minerals from which the soils have originated. The contribution of these sources to soluble fractions or fractions available to plant depends on the degree of weathering.

Aqua regia is rather often used in the determination of soil total heavy metal contents (KICK et al. 1980, NASSEEM 1980, COTTENIE et al. 1982). It does not, however, result in complete digestion of all minerals, but results satisfactory for many purposes are obtained. The aim of the present study was to compare the recovery of Cd, Cr, Ni, Hg, and Pb using the aqua regia method and $HF-HNO_3-HClO_4$ digestion.

MATERIAL AND METHODS

Twenty-seven soil samples covering a wide range of variation in their characteristics and geological origin were collected mostly from the plough layer from Egypt, Finland and the Federal Republic of Germany (Baghdady and Sippola 1983). Some additional samples of Finnish soils from areas where experiments with heavy metals had been carried out or where pollution by industry was known to be considerable were analysed. The results of these samples are not given in the Tables but some comments are made when discussing the results.

The soil samples were prepared for determinations and their physical and chemical properties were determined as described by Baghdady and Sippola (1983). The soil total heavy metal content was determined by two methods: the first was an aqua regia method (AR) according to Kick et al. (1980) and Baghdady and Sippola (1983); the second was $HF-HNO_3-HClO_4$ digestion (HHH) as described by Fisher and Fechter (1982). The solutions obtained were analysed for Ni and Pb using atomic absorption with an air-acetylene flame and a standard addition method. Cadmium in the HHH extract and chromium were determined with carbon rod equipment. Cadmium from the AR extract was concentrated for flame determination using a methylisobutyl ketone and hydrazinium sulphate – potassium iodate system. The mercury in the AR extract was analysed using the cold vapor method as suggested by Cottenie et al. (1982).

Table 1. Some chemical characteristics of the investigated soils.

	Number of soil samples	pH	$CaCO_3$ %	Org. C %	CEC me/100 g	Clay % < 2 µm
Egyptian soils	11					
mean		8,3	5,0	1,5	53,6	49
range		7,6–9,0	1,4–23,4	0,5–2,3	15–65	30–64
Finnish soils	10					
mean		5,9	–	7,8	51,8	29
range		4,6–7,2	–	0,2–26,9	15–155	5–78
German soils	6					
mean		6,4	1,3	1,0	20,4	11
range		4,8–8,4	0,3–6,0	0,4–1,8	15–30	3–19

RESULTS AND DISCUSSION

Because of the very different sources of the samples they are grouped in Table 2 according to their origin. The results show that AR extracted soil cadmium almost completely. The mean extraction percentages, which were based on results obtained using the HHH method were 97, 80 and 120 % in Egyptian, Finnish and German soils, respectively. The high values obtained for German soils may be due to volatilization of cadmium during the destruction stage of the HHH method. At the final stage HCl is added and the residue is dissolved by heating, at which point $CdCl_2$ may have volatilized. The high cadmium level in German soils was likely to promote the loss.

The error of determination is also relatively large when determining low cadmium contents. Direct determination of cadmium in the AR extracts resulted in extraction percentages of less than 30 %, indicating matrix problems. Solvent extraction, which was finally

Table 2. Mean contents (mg/kg) and ranges of some heavy metals extracted with aqua regia (AR) and HF–HNO_3–$HClO_4$ (HHH) from soils from Egypt, Finland and Germany.

	Number of	Cd		Cr		Hg	Ni		Pb	
	soil samples	AR	HHH	AR	HHH	AR	AR	HHH	AR	HHH
Egyptian soils	11									
mean		0,10	0,11	78	117	0,024	64	66	13	19
range		0,05–0,19	0,05–0,25	33–99	39–150	0,015–0,030	20–74	17–75	7–23	16–28
Finnish soils	10									
mean		0,23	0,28	44	69	0,071	20	21	18	29
range		0,10–0,38	0,17–0,40	6–111	6–142	0,02–0,14	3–56	4–52	4–37	14–39
German soils	6									
mean		0,42	0,36	44	60	0,058	15	17	20	30
range		0,09–1,02	0,09–0,93	7–120	13–137	0,03–0,15	6–25	9–23	13–31	22–48

adopted, gave much higher cadmium contents, but this procedure is likely to increase variation.

Compared to earlier reports of cadmium contents in similar soils, it can be seen that, when using boiling 5 % HNO_3 for extraction of ashed samples, HÅRDH (1977) reported lower results for Finnish soils. The difference between mean values was almost threefold, but 5 % HNO_3 is a weaker extractant than aqua regia. In the case of German soils, lower values were obtained in the present study than by KICK et al. (1980), who reported the range of AR extractable cadmium as 0,15 to 3 mg/kg. The small number of samples in each group in the present study does not, however, permit further conclusions.

Aqua regia also extracted nickel almost completely. The mean extraction percentages ranged from 83 to 99 % in the three soil groups. The high amounts of nickel in Egyptian soils were most easily dissolved by aqua regia. Relatively high nickel contents of Egyptian soils have also been shown by ELSOKKARY (1978). The mean nickel contents in Finnish and German soils were one third of that in Egyptian soils, and are at the level indicated in studies with more numerous samples. VUORINEN (1958) reported the total nickel content in Finnish soils to be 23 mg/kg and KICK et al. (1980) found a range from 2 to 76 mg/kg in German soils, using aqua regia.

An average of two thirds of the total chromium was extracted by aqua regia and the proportion of total lead was somewhat lower. In contrast, some additional samples which are not included in Table 2 and which were polluted by lead, had contents ranging from 665 to 3340 mg/kg (AR method); almost 100 % extraction was obtained. This shows that aqua regia extraction is very suitable for indicating contamination.

Due to the volatility of mercury none of this element was found in HHH extracts. There is thus only data for the AR extracts. The mean mercury value for Finnish soils was higher than that of the two other groups, although the range was similar to that of German soils. RAUTAPÄÄ et al. (1979) reported an even higher mean mercury content of 0,11 mg/kg for Finnish soils. Their material included samples from experimental fields where fungicides containing mercury has been used. In this study a similar sample contained 0,4 mg/kg mercury, showing that application of fungicides containing mercury leads to accumulation in soil. A dose of 100 tn/ha of sewage sludge was also found to increase soil contents, from 0,12 to 0,21 mg/kg.

The above results indicate that although aqua regia does not completely extract heavy metals from soil it appears to be very suitable for characterizing soils according to their degree of pollution.

REFERENCES

BAGHDADY, N.H. & SIPPOLA, J. 1983. Total heavy metal recovery by aqua regia in soils of different origins. Ann. Agr. Fenn. 22: 175–185.

COTTENIE, A., VERLOO, M., KIEKENS, L., VELGHE, G. & CAMERLYNCK, R. 1982. Chemical analysis of plants and soils. Lab. of Analytical and Agrochemistry. State Univ. Ghent – Belgium. 63 p. Ghent.

ELSOKKARY, I.H. 1978. Contamination of roadside soils and plants near highway traffic with Cd, Ni, Pb and Zn in Alexandria district, Egypt. Studies in Environmental Sci. I: 25–28.

FISHER, W.R. & FECHTER, H. 1982. Analytische Bestimmung und Fraktionierung von Cu, Zn, Pb, Cd, Ni and Co in Böden und Unterwasserböden. Z. Pfl.ernähr. Bodenkunde 145: 151–160.

FRANK, R., ISHIDA, K. & SUDA, P. 1976. Metals in Agricultural Soils of Ontario, Canad. J. Soil Sci. 56: 181–196.

HÅRDH, J.E. 1977. The heavy metals in alimentary crops and in soil. J. Sci. Agr. Soc. Finland 49: 209–220.

KICK, H., BÜRGER, H. & SOMMER, K. 1980. Gesamtgehalte an Pb, Zn, Sn, As, Cd, Hg, Cu, Ni, Cr und Co. Landw. Forsch. 33: 12–22.

MITCHELL, R.L. 1955. Trace elements. In Bear (Ed). Chemistry of the soil p. 253–285.

NASSEEM, M.G. 1980. Determination of total Cu and Zn contents of Egyptian soils using three different methods. Plant and Soil 55: 327–330.

RAUTAPÄÄ, L., PYYSALO, H., ROVIO, P. & BLOMQVIST, H. 1979. Mercury in cultivated soil in Finland. Ann. Agr. Fenn. 18: 87–91.

VUORINEN, J. 1958. On the amounts of minor elements in Finnish soils. J. Scient. Agric. Soc. Finl. 30: 30–35.

Manuscript received August 1983

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SELOSTUS

Kuningasvesi maan elohopean, kadmiumin, kromin, lyijyn ja nikkelin uuttajana

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Haitallisten raskasmetallien kertymiseen viljelysmaihin on teollistumisen ja jätteiden maatalouskäytön lisääntyessä kiinnitetty yhä enenevässä määrin huomiota. Maan saastuneisuuden seurantaan on käytetty mm. kuningasvesiuuttoa, mikä vahvana hapettajana liuottaa lähes kokonaismäärän. Tämän työn tarkoituksena oli selvittää kuningasveden uuttokykyä ominaisuuksiltaan hyvin erilaisista maista.

Tulosten mukaan kuningasvesi uutti kadmiumia ja nikkeliä keskimäärin kaikki Egyptistä, Saksasta ja Suomesta otetut näytteet käsittävässä aineistossa yli 90 % fluorivetyhajotuksella saadusta kokonaismäärästä. Suomesta otetuista näytteistä uuttui tätä keskimäärää vähemmän: 80 % kadmiumista ja 86 % nikkelistä, 64 % kromista ja 58 % lyijystä. Lyijysulaton läheisyydestä otetuista näytteistä, joiden pitoisuus oli huomattavasti tavanomaista korkeampi, 665–3340 mg/kg, kuningasvesi uutti lyijyn lähes täydellisesti. Vaikka kuningasvesi ei näin ollen uuta maasta raskasmetallien kokonaismäärää, näyttää se soveltuvan hyvin saastuneisuuden arvioimiseen.

Ilman edellä mainittuja saastuneita näytteitä laskettu keskimääräinen lyijypitoisuus 29 mg/kg Suomen aineistossa oli korkeampi kuin Vuorisen 1958 esittämä keskiarvo 16 mg/kg. Tämän tutkimuksen pienen näyteaineiston takia, vain 10 näytettä, ei kuitenkaan voida tehdä johtopäätöstä, että viljelymaiden lyijypitoisuus olisi nykyään aikaisempaa korkeampi. Sen sijaan viemärilietekokeista otettujen näytteiden korkea kadmiumpitoisuus (0,40–0,89 mg/kg) osoittaa, että lietteen käyttö lisää maan kadmiumpitoisuutta. Samoin elohopeapitoisten kasvinsuojeluaineiden käyttö lisää maan elohopeapitoisuutta. Niinpä eräältä koekentältä otetun maanäytteen elohopeapitoisuus oli viisinkertainen normaaliarvoon verrattuna.

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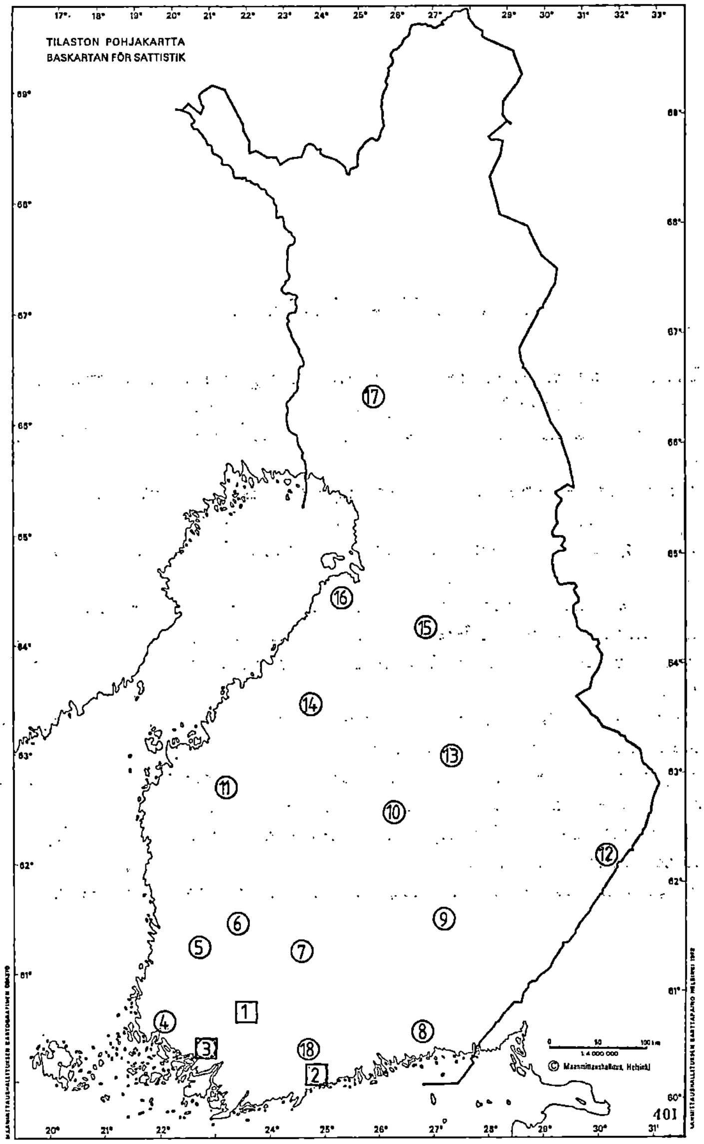

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Helsinki 1984. Government Printing Centre ISSN 0570-1538