EFFECTS OF HIGH AND LOW GLUCOSINOLATE RAPESEED MEAL AND SOYBEAN MEAL ON THYROID FUNCTION IN PIGS AND RATS

By Philip J. McKinnon and John P. Bowland
Animal Science Department, The University of Alberta, Edmonton, Alberta, Canada T6G 2E3

Recent studies have demonstrated a marked improvement in the nutritional characteristics of rapeseed meal (RSM) from low glucosinolate varieties of rape compared with meal produced from older, high glucosinolate, varieties. Although older varieties have been shown to cause thyroid enlargement and a reduction in circulating thyroid hormone levels, little information is available on the effects of low glucosinolate RSM on the thyroid. Bowland (1975) found that tetraiodothyronine (T-4) levels tended to be lower in young pigs fed low glucosinolate RSM than in those fed soybean meal. Grandhi et al. (1976) found similar results. The objective of the present study was to determine the effects of low glucosinolate - low erucic acid RSM (cv. Tower = 00-RSM), commercially available RSM (C-RSM) or soybean meal (SBM) on thyroid function in pigs and rats.

METHODS AND MATERIALS

Experiment 1: Thirty-three crossbred pigs averaging 5.6 kg were allotted at random within sex and litter-mate groups to five experimental diets containing 00-RSM or C-RSM as complete or partial (50% of supplemental protein) replacements for SBM. Isonitrogenous and isocaloric diets were based on wheat and barley and contained 18% crude protein and 3170 kcal/kg digestible energy. Dietary formulation and details of experimental procedure have been reported previously (McKinnon and Bowland, 1977).

The experiment was carried out from 4 to 10 weeks of age and animals were maintained individually in a temperature controlled building (21-22°C). Feed and water were available ad libitum. Three barrows and four gilts were assigned to each treatment except that only two barrows and three gilts were available for the 00-RSM+SBM treatment.

At the end of the fifth week of the experiment, all pigs were bled by anterior vena cava puncture for serum T-4 radioimmunoassay and cholesterol analysis. All pigs were sacrificed after 6 weeks, the thyroids were removed immediately, weighed, fixed in 10% buffered formalin and later sectioned and stained with haematoxylin and eosin.

Experiment 2: Eighty crossbred pigs averaging 5.3 kg were allotted to the five dietary treatments as in Experiment 1. Experimental procedure was as reported above except that one barrow and one gilt were maintained together and the experiment was replicated in two time periods. Two pigs died of causes unrelated to the experiment.

Pigs were bled for T-4 determinations at the end of the sixth week on experiment and analyses of T-3 uptake and T-3 radioimmunoassay (T-3 RIA) were made. A value of a "free thyroxine index", which measures the physiologically active T-4, was calculated: (T-3 uptake/100) x T-4 = Free T-4.

Experiment 3: Fifty weanling rats of the Sprague-Dawley strain were fed the five diets used in the pig experiments from 3 - 7 weeks of age with four females and six males per treatment. All males and two females were sacrificed at the end of the experiment and thyroids removed and weighed.

Appropriate analyses of variance were computed and means were compared using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Experiment 1: Thyroid weight of pigs fed the C-RSM+SBM diet was greater ($P<.05$) than in pigs fed other diets, but the ratio of thyroid weight/body weight of pigs fed both diets with C-RSM was greater than that of pigs fed other diets (Table 1). These results are indicative of thyroid hypertrophy of pigs fed C-RSM. An important finding was that thyroid weight/body weight of pigs fed the OO-RSM diet was greater ($P<.05$) than pigs fed the SBM diet, although less ($P<.05$) than pigs fed either C-RSM diet. This indicates that C-RSM had a greater hypertrophic effect on the thyroid than did OO-RSM.

TABLE 1. WEIGHTS AND HISTOLOGY OF THYROID GLANDS OF PIGS - EXPERIMENT 1.

	Protein Source					
	SBM	OO-RSM	OO-RSM+SBM	C-RSM	C-RSM+SBM	SEM+
Number of pigs	7	7	5	7	7	
Thyroid wt. g	3.1^{b}	3.7^{b}	3.3^{b}	4.0^{b}	6.6^{a}	0.36
Thyroid wt./body wt. g/kg	0.14^{c}	0.21^{b}	0.19^{b}	0.30^{a}	0.33^{a}	0.01
T-4 µg/100 ml	6.0^{a}	4.2^{b}	5.7^{a}	3.5^{b}	3.9^{b}	.31
Cholesterol mg/100 ml	125^{b}	138^{a}	118^{b}	138^{a}	136^{a}	3.25

+ SEM = Standard error of means
a,b,c within a row, means with the same or no letter do not differ ($P<.05$).

T-4 levels of pigs fed the SBM and OO-RSM+SBM diets were greater ($P<.05$) than pigs fed either diet with C-RSM or the OO-RSM diet. However, the effects of complete replacement of SBM with OO-RSM did not appear as severe as was found with complete replacement with C-RSM. These results are in agreement with the work of Bowland (1975) and Grandhi et al. (1976) who found lower T-4 levels of pigs fed OO-RSM than those fed SBM as the protein source.

Cholesterol levels, which when used with other measures of thyroid status provide information on thyroid function, showed that pigs fed the OO-RSM diet or both diets with C-RSM had higher ($P<.05$) cholesterol levels than pigs fed the SBM or OO-RSM+SBM diets. Animal tallow, which may elevate cholesterol levels, was added to produce isocaloric diets, with 4.0% used in the OO-RSM and C-RSM diets, 2.5% in the diets with partial substitution of protein sources and 1.5% in the SBM diet. It is not expected that these small differences in tallow levels would produce the differences observed. Although not completely consistent, the serum cholesterol levels do agree with the thyroid weight and hormone determinations and thus, are indicative of some degree of thyroid dysfunction of pigs fed the OO-RSM diet and both diets with C-RSM.

Histological examination of the thyroid glands did not show apparent differences due to diets at the cellular level under light microscopy. However, this does not rule out the possibility of impairment of thyroid function.

Experiment 2: In period 1, no significant differences were found for T-4, T-3 RIA of Free T-4 but T-3 uptake was greater ($P<.05$) for pigs fed the SBM diet than other diets (Table 2). However, in period 2,

T-4 levels were higher ($P < .05$) for pigs fed the SBM and OO-RSM+SBM diets than for pigs fed the C-RSM or C-RSM+SBM diets. Response of pigs fed the diet with OO-RSM was intermediate. T-3 uptake levels of pigs fed the SBM diet were greater ($P < .05$) than in pigs fed other diets, as was found in period 1. Also, T-3 uptake in pigs fed the C-RSM+SBM diet was greater ($P < .05$) than in pigs fed either diet with OO-RSM or the C-RSM diet. T-3 RIA was not different for any diet, but Free T-4 was greater ($P < .05$) in pigs fed the SBM diet and less ($P < .05$) for pigs fed the C-RSM diet than for pigs fed the other three diets.

Experiment 3: With rats, no significant treatment differences were found in absolute thyroid weight or the ratio of thyroid weight to body weight (Table 3). These findings are not consistent with the results of the pig experiment where thyroid enlargement was clearly evident. As well, a severe depression in performance of the rats fed both C-RSM diets has been reported (McKinnon and Bowland, 1977). The present findings may be a result of the large between-animal variation and small number of animals, but other authors have shown similar variable results in thyroid weights of rats fed RSM.

TABLE 2. SERUM THYROID HORMONE LEVELS OF PIGS - EXPERIMENT 2.

	Protein Source					
	SBM	OO-RSM	OO-RSM+SBM	C-RSM	C-RSM+SBM	SEM+
Period 1						
Number of pigs	8	8	8	8	8	
T_4 µg/100 ml	4.2	4.3_b	4.0_b	3.8_b	4.6_b	0.40
T_3 uptake %	40.5^a	36.6^b	36.4^b	35.1^b	36.4^b	0.71
T_3 RIA ng/100 ml	133.2	134.1	128.2	152.4	143.7	11.6
Free T-4	1.70	1.57	1.45	1.33	1.66	0.16
Period 2						
Number of pigs	7	8	8	7	8	
T_4 ug/100 ml	2.8^a	2.5^{ab}	2.8^a	1.7^c	2.1^{bc}	0.18
T_3 uptake %	37.9^a	31.5^c	32.0^c	32.1^c	35.0^b	0.93
T_3 RIA ng/100 ml	61.1	56.0	70.7	54.0	60.5	10.03
Free T-4	1.07^a	0.81^b	0.89^b	0.56^c	0.74^b	0.06

+SEM = Standard error of means

a,b,c within a row, means with the same or no letter do not differ ($P < .05$)

In summary, it was demonstrated gravimetrically that thyroid hypertrophy occurred in young pigs when OO-RSM completely replaced SBM, but it was less severe than when C-RSM partially or completely replaced SBM. T-4 levels in particular showed an impairment of thyroid function of pigs fed both diets with C-RSM and suggested some impairment of thyroid function of pigs fed OO-RSM as a complete replacement for SBM. Such impairment was not found when half the SBM was replaced with OO-RSM.

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TABLE 3. INFLUENCE OF DIETS ON WEIGHTS OF RAT THYROIDS - EXPERIMENT 3

	Protein Source					
	SBM	00-RSM	00-RSM + SBM	C-RSM	C-RSM + SBM	SEM[+]
Number of animals	8	8	8	8	8	
Thyroid wt, mg	11.9	11.4	11.0	9.6	9.7	0.71
Thyroid wt./body wt. mg/kg	6.1	6.3	5.8	6.3	6.1	0.32

[+]SEM = Standard error of means

REFERENCES

Bowland, J.P., 1975. Evaluation of low glucosinolate - low erucic acid rapeseed meals as protein supplements for young growing pigs, including effects on blood serum constituents. Can. J. Anim. Sci. 55: 409-419.

Grandhi, R., S.J. Slinger, R.G. Brown and R.R. Hacker, 1976. Thyroid hormone synthesis in rapeseed meal fed pigs. J. Anim. Sci. 43: 252-253. (Abstr.).

McKinnon, P.J. and J.P. Bowland, 1977. Influence of low glucosinolate - low erucic acid rapeseed meal (cultivar Tower), commercial rapeseed meal and soybean meal on thyroid metabolism in young pigs and rats. Can. J. Anim. Sci. 57: 663-678.