EFFECTS OF AMMONIATION, IODINATION AND SUPPLEMENTATION OF AVOPARCIN ON THE NUTRITIONAL VALUE OF RAPESEED MEALS

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Summary

Supplementation of iodine at the level of 3.5 mg/kg reduced weight gain of the rats fed rapeseed oil meal (ROM) diets. Treatment of ROM with ammonia at the level of 2 or 4% tended to increase metabolizable energy value and availability of dry matter, crude protein and crude ash of ROM in the chicken. Potential goitrin level of ROM was reduced by ammoniation at 6% level, while the level of potential isothiocyanates was increased by ammoniation.

Treatment of ROM with ammonia at the level of 3% and above reduced weight gain of the chickens fed treated ROMs. Weight of thyroid glands of the birds increased as the level of ammoniation of ROM increased. Supplementation of Avoparcin to the diets containing ROM improved weight gain and dressing percentage of the broiler chickens.

(**Key Words**: Rapeseed Meal, Ammoniation, Glucosinolates, Avoparcin, Rats, Broilers)

Introduction

Rapeseed oil meal (ROM) is fairy good source of protein and its amino acid composition is similar to other protein supplements such as soybean meal (SBM). However, some difficulties have been experienced when ROM is used in the diets of monogastric animals. One of the main problems encountered has been related to the presence of glucosinolates in the meal. Glucosinolates are hydrolyzed by enzyme thioglucoside glucohydrolase (myrosinase) to yield various hydrolysis products. Aglucone products formed by hydrolysis of glucosinolates are more or less antithyroid substances (VanEtten, 1969). Enzymatic hydrolysis of progoitrin (2-hydroxy-3-butenyl glucosinolate) yields 2-hydroxy-3-butenyl isothiocyanate which is unstable and cyclizes to 5-vinyl-2-thiooxazolidone. This cyclic compound is also called goitrin due to its strong goitrogenic effect (Kjaer, 1960). Other isothiocyanates may exert a goitrogenic effect by formation of thiourea derivatives (Greer, 1950, 1962) or by formation of thiocyanate ion (VanEtten, 1969).

Supplementation of iodinated casein to the diet containing ROM reduced weight of thyroid glands of the chickens (Klain et al., 1956) and pigs (Nordfeldt et al., 1959) but did not improve growth rate. Supplementation of iodinated casein (50-200 mg/kg) or calcium iodate (0.14-0.28 ppm iodine) to the pig diets containing canola meal did not produce significant responses in gain and feed efficiency (Bell et al., 1980)

Blake (1983) produced ammoniated canola meal by treating 5% (w/w) anhydrous ammonia at 105℃. Ammonia treatment significantly increased nitrogen content by 8.3% and reduced glucosinolates content approximately 40%. When the ammonia treated canola meal was included at the level of 20% in the chicken diet, availability of lysine, body weight, feed conversion and thyroid size were not significantly affected (Goh et al., 1983). In a rat feeding trial, however, plasma lysine concentrations were lower in rats fed the ammoniated meals indicating decreased absorption of lysine (Keith and Bell, 1984). Ammoniation of mustard meal reduced glucosinolates by over 80% and reduced lysine by 20 % as well but increased crude protein from 44.6 to 51.1% on dry basis (Bell et al., 1984).

Jensen and Thomsen (1980) reported that Avoparcin supplementation to the diet containing ROM improved performance of the broiler chi-

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ckens. Growth promoting effect of Avoparcin increased when the level of protein and lysine in the diet was lowered (Kirchgessner and Roth, 1981).

The objectives of this study were (1) to assess the influences of feeding diets containing ROMs hydrolyzed with mustard seed powder, ammoniated or supplemented with iodine on the performance of the rats (Experiment 1); (2) to study chemical characteristics of ROM and effects of ammoniation on the metabolizable energy value and levels of hydrolysis products of glucosinolates in ROM (Experiment 2); (3) to study effects of feeding diets containing ammoniated ROMs on the performance of broiler chickens (Experiment 3); (4) to examine the effects of supplementation of Avoparcin in the broiler diet with or without ROM (Experiment 4).

Materials and Methods

Experiment 1

Thirty six weanling male Wistar rats were divided into 6 groups and housed randomly in the individual cages. Each group was placed on one of the following six experimental diets; Basal + Korean ROM (ROM), Basal + Canadian ROM (Canola), Basal + Korean ROM hydrolyzed with mustard seed powder (Hydrolyzed ROM), Basal + ammoniated Korean ROM (Ammoniated ROM), Basal + Korean ROM + iodine (Iodized ROM), and Basal + Korean ROM hydrolyzed with mustard seed powder + iodine (Iodized, hydrolyzed ROM).

Basal diet was formulated with corn (58%), soybean meal (26.6%), fish meal (8%), animal fat (5%), D,L-methionine-50% (0.2%), dicalcium phosphate (1.5%), salt (0.2%), commercial vitamin and mineral premix (0.5%). Rapeseed meal was included at the level of 20% replacing the basal diet in each treatment.

For the hydrolysis of ROM, mustard seed powder was added to ROM at the level of 5% and then thoroughly mixed along with distilled water of twice the weight of ROM. The mixture was incubated for 24 hrs at 37℃ and then dried. Ammoniation of ROM was conducted by spraying diluted aqueous ammonia (12.5% NH_3 concentration) at the level of 10% of ROM treated, followed by incubation at 37 ℃ for one week. Iodized diets were supplemented with KI at the level of 3.5 mg/kg iodine.

Experiment 2

General composition, Ca and P of ROM were analyzed by A.O.A.C. (1984) methods. Analysis of amino acids and other minerals were conducted with automatic amino acid analyzer and atomic absorption spectrometer, respectively. Energy utilization of ROM was determined by apparent metabolizable energy (AME) method (Hill and Anderson, 1958) and true metabolizable energy (TME) method (Sibbald, 1986). Twelve week old cockerels of White Leghorn breed were employed for the determination.

Ammoniation of ROM was conducted at 0, 2, 4 and 6% ammonia level using a similar procedure as described in Experiment 1. Nutrients availability of treated ROMs were determined by using the procedure employed in TME determination. Hydrolysis products of glucosinolates in ROM were determined by the method of Appelqvist & Joseffson (1967) using UV-spectrophotometer.

Experiment 3

Two broiler feeding trials were conducted for 6 weeks each. In Experiment 3-A, 160 hatched male broiler chickens were fed 4 experimental diets; 0, 1.5, 3 and 4.5% ammoniated ROM diet, in which ammoniated ROMs were included at the level of 15%.

In Experiment 3-B, 24 chickens were fed 3 experimental diets; 0, 3 and 6% ammoniated ROM diet, in which ammoniated ROMs were used at the level of 20%. Nutrients availabilities of the experimental diets were determined by a metabolic trial at 7 weeks of age of the birds.

Experiment 4

Two hundred fifty hatched male broiler chickens were divided into 25 groups of 10 birds each and fed in raised floor batteries. Five groups were placed on one of the following five experimental diets; Soybean meal (SBM) diet, SBM diet + Avoparcin 10 mg/kg, ROM diet, ROM diet + Avoparcin 10 mg/kg, and ROM diet + Avoparcin 15 mg/kg

Diets were formulated using computer to have isocalorie and isonitrogen, and ROM diets contained Indian ROM at the level of 8%. Dressing percentage of the birds was measured after removing head, feet, feathers and intestinal organs.

For the statistical analysis of the results, analysis of variance and Duncan's Multiple Range Test (Steel and Torrie, 1980) were used to test for significance between treatment means.

Results and Discussion

Experiment 1

Weight gain, feed intake and feed efficiency of the rats are shown in table 1. Weight gains of the rats fed Canola, Ammoniated ROM, and ROM were significantly ($p < 0.01$) greater than that of Iodized, hydrolyzed ROM. Weight gain of the rats fed Hydrolyzed ROM and Iodized ROM were not significantly different from others. Feed intake of the rats fed Ammoniated ROM, Canola, and ROM were significantly ($p < 0.01$) greater than that of Iodized, hydrolyzed ROM. Those of Hydrolyzed ROM and Iodized ROM were not significantly different from others. The differences of feed efficiency among treatments were not statistically significant.

Weight of thyroid glands, liver and kidneys per 100 g body wt of rats are shown in table 2. The weight of thyroid glands of the rats fed Hydrolyzed ROM and Iodized, hydrolyzed ROM were significantly ($p < 0.01$) heavier than those of rats fed ROM, Canola, Ammoniated ROM and Iodized ROM. The weight of liver and kidneys were not significantly different among treatments.

Results of the experiment indicate that treatments of ROM influence weight gain and feed intake without significant influence on feed efficiency. Canadian ROM (Canola) showed best weight gain and feed efficiency probably due to low glucosinolates content and properly controlled processing conditions. Mustard seed powder has been known to be a rich source of myrosinase. Thus, hydrolysis of ROM with mustard seed powder might have produced goitrin and isothiocyanates from glucosinolates of ROM. Enlarged thyroid glands of the rats fed hydrolyzed ROMs are the evidence of goitrin production (Paik et al., 1980). Hydrolysis of ROM tended to reduce weight gain and feed intake probably due to the production of goitrin and isothiocyanates. Nord-

TABLE 1. WEIGHT GAIN, FEED INTAKE, AND FEED EFFICIENCY OF THE RATS FED ROM DIETS FOR 6 WEEKS (EXP. 1)

Treatments	Weight gain (g)	Feed intake (g)	Feed efficiency
ROM	218.6^{a}	662.7^{a}	3.04
Canola	225.7^{a}	663.3^{a}	2.95
Hydrolyzed ROM	206.4^{ab}	615.6^{ab}	2.98
Ammoniated ROM	219.5^{a}	683.8^{a}	3.12
Iodized ROM	194.9^{ab}	610.8^{ab}	3.14
Iodized, hydrolyzed ROM	173.7^{b}	542.1^{b}	3.13
SEM	9.8	27.2	0.07

a,b: Values with different superscript in the same column are significantly differnet at $p < 0.01$.

TABLE 2. WEIGHT OF THYROID GLANDS, LIVER AND KIDNEYS OF RATS, PER 100 G OF BODY WEIGHT (MEAN ± SD) (EXP. 2)

Treatment	Thyroid glands (mg)	Liver (g)	Kidneys (g)
ROM	6.61 ± 2.05^{a}	4.96 ± 0.42	0.958 ± 0.047
Canola	4.89 ± 0.74^{a}	4.52 ± 0.58	0.869 ± 0.028
Hydrolyzed ROM	10.89 ± 1.91^{b}	4.90 ± 0.52	0.849 ± 0.076
Ammoniated ROM	5.22 ± 1.71^{a}	4.47 ± 0.21	0.894 ± 0.069
Iodized ROM	5.07 ± 1.39^{a}	4.25 ± 0.21	0.876 ± 0.082
Iodized, hydrolyzed ROM	11.57 ± 3.51^{b}	4.73 ± 0.54	0.868 ± 0.067

a,b: Values with different superscript in the same column are significantly different at $p < 0.01$.

feldt et al., (1959) and Ochetim et al., (1980) indicated that iodine supplementation alleviates goiter. Supplementation of iodine to ROM and Hydrolyzed ROM diets did not reduce the size of thyroid glands but reduced weight gain. Present results indicate that excessive supplementation of iodine to ROM diets may be detrimental. Ammoniation of ROM at the present level (1.25% in NH_3 basis) did not significantly influence performance or weight of organs of the rats.

Experiment 2

General composition, amino acids and mineral contents of ROM are shown in table 3. The chemical compositions of Korean ROM were similar to those of Canadian ROM. Metabolizable energy contents of ROMs are shown in table 4.

Average metabolizable energy content of Korean ROM was 1,877 kcal in AME, 1,818 kcal in AMEn, 2,414 kcal in TME and 2,350 kcal in TMEn per kg of dry matter (DM). Average metabolizable energy content of Canadian ROM was 1,933 kcal in AME, 1,846 kcal in AMEn, 2,955 kcal in TME and 2,833 kcal TMEn per kg DM.

The potential goitrin levels of ROMs are shown in table 5. The level of goitrin was highest in Chilean ROM being 6.40 mg and lowest in Indian ROM being 1.05 mg. The level of isothiocyanate was the highest in local mustard seed powder being 4.46 mg and the lowest (not detectable) in Canadian ROM (mash). Table 5 also shows that goitrin level of Korean ROM (4.37 mg) was not affected by ammoniation at the level of 2 or 4% but reduced to 2.52 mg at 6% ammoniation. The level of isothiocyanate in ROM tended to increase by ammoniation.

TME values of ammoniated Korean ROM are shown in table 6. Ammoniation of ROM increased TME showing the highest value at 4 % ammoniation. Nutrients availability of ammoniated ROMs, which were determined with samples obtained from TME bioassay procedure, are shown in table 7. Availability of crude protein of ROMs ammoniated at 2 or 4% was significantly ($p < 0.05$) higher than that of untreated ROM. Availability of dry matter and crude ash tended to be higher in ROMs ammoniated at 2 or 4% than in ROM ammoniated at 6% or untreated ROM.

Metabolizable energy value of ROM varies widely depending on the source of reports. Reported ME values of ROMs were 1,670 kcal/kg DM (Sibbald and Slinger, 1963), 1,230, 1,313 and 1,782 kcal/kg DM (Lodhi et al., 1969), and 2,295 kcal/kg ADM (Sell, 1966). AMEn values of ROM were 1,530 kcal/kg DM (Sibbald and Slinger, 1963), 2,120 kcal/kg ADM (Sell, 1966),

TABLE 3. CHEMICAL COMPOSITION OF RAPESEED OIL MEAL (EXP. 2)

Composition	Korean ROM	Canadian ROM
General composition (%)		
Moisture	13.09	11.70
Crude protein	34.20	33.59
Crude fat	2.09	3.22
Crude fiber	10.03	6.90
Crude ash	7.91	6.90
N.F.E.	32.68	37.66
Amino acids (%)		
Lysine	1.85	1.64
Histidine	0.92	0.92
Arginine	1.44	1.67
Aspartic acid	2.32	2.02
Threonine	1.43	1.45
Serine	1.50	1.32
Glutamic acid	5.99	6.04
Proline	2.80	1.73
Glycine	1.59	1.44
Alanine	1.49	1.36
Cystine	0.23	0.63
Valine	1.48	1.66
Methionine	0.42	0.62
Isoleucine	1.13	1.29
Leucine	2.23	2.12
Tyrosine	0.47	0.77
Phenylalanine	1.32	1.10
Minerals (%)		
Ca	0.60	0.73
P	0.94	1.06
K	3.00	3.25
Na	0.30	0.27
Mg	0.47	0.46
Fe	0.035	0.016
Mn	0.008	0.004
Zn	0.007	0.008
Cu	0.001	0.001

TABLE 4. METABOLIZABLE ENERGY CONTENT OF RAPESEED OIL MEALS DETERMINED WITH COCKERELS (KCAL / KG DM)(MEAN ± SD) (EXP. 2)

Items	Korean ROM	Canadian ROM
AME	1,877 ± 332	1,933 ± 335
AMEn	1,818 ± 333	1,846 ± 342
TME	2,414 ± 195	2,955 ± 520
TMEn	2,350 ± 200	2,833 ± 650

1,682 kcal/kg ADM (Lee et al., 1973) and 1,843 kcal/kg ADM (Paik et al., 1975). TME and TMEn values of ROM were reported to be 2,270-3,060 kcal and 2,055-2,533 kcal/kg DM, respectively (Sibbald, 1986).

Except TMEn value of Canadian ROM, other metabolizable energy values of ROM determined in the present experiment are within the range of the published data. Increase of TME values of ammoniated ROMs, especially 2 and 4% ammoniated, may be due to the improved ava-

TABLE 5. CONTENT OF HYDROLYSIS PRODUCTS OF GLUCOSINOLATES IN RAPESEED OIL MEAL (MG / G) (EXP. 2)

ROMs	Goitrin	Isothiocyanate
Korean ROM	4.37	0.46
Korean ROM (2% ammoniation)	4.47	0.78
Korean ROM (4% ammoniation)	4.35	0.72
Korean ROM (6% ammoniation)	2.52	0.84
Canadian ROM (mash)	3.12	ND
Canadian ROM (pellet)	1.48	0.99
Indian ROM	1.05	1.51
Mustard seed powder	1.71	4.46
Chinese ROM	2.41	0.48
Chilean ROM	6.40	0.86

TABLE 6. TRUE METABOLIZABLE ENERGY CONTENT OF AMMONIATED KOREAN ROMS DETERMINED WITH COCKERELS (KCAL / KG DM) (MEAN ± SD) (EXP. 2)

TME	ROM	2% Ammoniated	4% Ammoniated	6% Ammoniated
TME	2,599 ± 191	2,771 ± 320	2,824 ± 222	2,647 ± 106
TMEn	2,475 ± 180	2,514 ± 309	2,566 ± 102	2,482 ± 125

TABLE 7. NUTRIENTS AVAILABILITY[1] OF AMMONIATED KOREAN RAPESEED OIL MEALS (%) (EXP. 2)

Treatments	DM	Crude protein	Crude fat	Crude fiber	Crude ash	N.F.E.
0% ammoniated ROM	40.1	21.7[b]	63.7	28.5	18.0	99.3
2% ammoniated ROM	44.9	50.4[a]	55.1	33.6	29.7	89.0
4% ammoniated ROM	48.4	48.4[a]	69.1	29.0	30.8	98.1
6% ammoniated ROM	41.7	29.6[ab]	63.6	28.5	21.5	100.0
SEM	3.44	6.81	5.66	1.68	4.03	4.51

[1] Determined with samples obtained from TME assay procedure using cockerels.
[a,b]: Values with different superscript are significantly different at $p < 0.05$.

ilability of dry matter and crude protein.

Giotrin level of ROM was reduced only at 6% ammoniation. Glucosinolates content of Canadian ROM could be reduced by the treatment with heat (105℃), steaming and 5% anhydrous ammonia (Blake, 1983). Increase of isothiocyanate level in the ammoniated ROM seems to be related to the formation of thiourea derivatives as a result of ammoniation. Isothiocyanates react with ammonia to form thiourea derivatives which is measured by UV-spectrophotometer in the quantitative analysis of isothiocyanates.

The results of Experiment 2 indicate that 2 or 4% ammoniation is proper to improve ME value and nutrients availability of ROM although 6% ammoniation may be required to reduce potential goitrin level of high glucosinolate ROMs.

Experiment 3

Formulas and chemical compositions of experimental diets used in Experiment 3 are shown in table 8. Weight gain, feed intake and feed efficiency of the broiler chickens of Experiment 3-A are summarized in table 9. Performance of the birds fed for 6 weeks were not significantly different among treatments. Numerically, however, weight gain and feed defficiency of the birds showed quardratic response to the level of ammoniation. Birds fed 1.5% ammoniated ROM diet performed better than other treatments while those fed 4.5% ammoniated ROM diet performed worse. Weekly weight gain data showed that birds fed 1.5% ammoniated ROM diet weighed less than those fed 0% ammoniated (untreated) ROM diet up to 4 weeks of age but weighed more after 5 weeks of age.

Nutrients availability of the experimental diets (Exp. 3-A) are shown in table 10. Availability of crude protein, crude fat and crude fiber tended to be higher in 1.5% ammoniated ROM diet but availability of NFE was higher in 4.5% ammoniated ROM diet than other treatments.

Weight gain, feed intake and feed efficiency of broiler chickens of Experiment 3-B are shown in table 11. Birds fed 3 or 6% ammoniated ROM diet gained significantly ($p < 0.01$) less weight than those fed 0% ammoniated (untreated) ROM diet. Birds fed 6% ammoniated ROM diet consumed significantly ($p < 0.05$) less feed than those fed untreated ROM diet but there was no significant difference in feed efficiency.

Table 12 shows contents of potential hydrolysis products of glucosinolates in ammoniated ROMs which were used in Experiment 3. Goitrin level of untreated ROMs were rather low (2.34 mg in Exp. 3-A and 2.45 mg in Exp. 3-B) and ammoniation did not lower them to any considerable extent. On the other hand, level of isothiocyanates of ROM increased as the level of ammoniation increased.

Weight of thyroid glands of the birds fed experimental diets (Exp. 3 A and B) are shown in table 13. Weight of thyroid glands in mg per 100 g body weight increased as the level of

TABLE 8. FORMULA AND CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS (EXP. 3)

Ingredients (%)	Exp. 3-A	Exp. 3-B
Corn, yellow	58.35	56.86
Rapeseed Oil Meal (ROM)	15.00	20.00
S.B.M. (44%)	13.80	9.97
Fish meal	7.00	7.00
Animal fat	3.96	4.46
D, L-Met (50%)	0.22	0.22
Calphos-16	0.91	0.88
Limestone	0.32	0.29
Salt	0.15	0.15
Lysine-HCl	0.09	0.14
Premix[1]	0.20	0.20
Total	100.00	100.00
Chemical composition[2] (%)		
Moisture	11.28	12.33
Crude Protein	19.72	21.00
Crude Fat	6.15	4.09
Crude Fiber	3.18	4.09
Crude Ash	5.61	5.37
N.F.E.	54.06	49.36
ME (kcal/kg)[3]	3,018	3,000
Ca	1.03	0.95
P	0.72	0.45

[1] This premix contains following amounts of micronutrients per kg: Vit.A 2,000,000 IU, Vit.D_3 400,000 IU, Vit.E 1,000 IU, Vit.K_3 200 mg, Vit.B_1 200 mg, Vit.B_2 1,000 mg, Vit.B_6 200 mg, Vit.B_{12} 1.0 mg, Vit.C 3,000 mg, Ca-pantothenate 2,000 mg, Niacine 3,500 mg, Choline chloride 20,000 mg, Folic acid 100 mg, Fe 4,000 mg, Cu 500 mg, Zn 10,000 mg, Mn 12,000 mg, Co 100 mg, I 100 mg.

[2] Average assay value of triplicate samples.

[3] Calculated value.

TABLE 9. WEIGHT GAIN, FEED INTAKE, FEED EFFICIENCY OF BROILER CHICKENS FED AMMONIATED ROM DIETS FOR 6 WKS (EXP. 3-A)

Treatments	Weight gain (g)	Feed intake (g)	Feed efficiency
0% ammoniated ROM diet	1,735.0	3,394.9	1.96
1.5% ammoniated ROM diet	1,742.3	3,344.3	1.92
3% ammoniated ROM diet	1,676.0	3,312.4	1.98
4.5% ammoniated ROM diet	1,618.5	3,224.9	1.99
SEM	35.49	82.58	0.02

TABLE 10. NUTRIENTS AVAILABILITY OF THE EXPERIMENTAL DIETS (%) (EXP. 3-A)

Treatment	Dry matter	Crude protein	Crude fat	Crude* fiber	N.F.E.**
0% ammoniated ROM diet	71.11	51.98	87.39	6.97^{ab}	85.15^{ab}
1.5% ammoniated ROM diet	71.61	54.10	89.29	15.50^{a}	85.36^{ab}
3% ammoniated ROM diet	69.46	50.06	87.10	5.78^{b}	83.88^{b}
4.5% ammoniated ROM diet	71.22	49.26	88.78	6.99^{ab}	86.38^{a}
SEM	0.87	2.31	1.71	2.63	0.32

^{a,b}: Values with different superscript in the same column are significantly different at $p < 0.01$ (**) or $p < 0.05$(*).

TABLE 11. WEIGHT GAIN, FEED INTAKE, FEED EFFICIENCY OF BROILER CHICKENS FED AMMONIATED ROM DIETS FOR 6 WKS (EXP. 3-B)

Treatments	Weight gain** (g)	Feed intake* (g)	Feed efficiency
0% ammoniated ROM diet	1,768.0^{a}	3,350.0^{a}	1.90
3% ammoniated ROM diet	1,631.2^{b}	1,180.0^{ab}	1.95
6% ammoniated ROM diet	1,613.7^{b}	3,107.5^{b}	1.93
SEM	11.03	55.06	0.029

^{a,b}: Values with different superscript in the same column are significantly different at $p < 0.01$ (**) or $p < 0.05$(*).

TABLE 12. CONTENTS OF HYDROLYSIS PRODUCTS OF GLUCOSINOLATES IN THE AMMONIATED ROMS (MEAN ± SD) (EXP. 3 A AND B)

Treatments	Goitrin (mg/g)		Isothiocyanate (mg/g)	
	Exp. 3-A	Exp. 3-B	Exp. 3-A	Exp. 3-B
0% ammoniated ROM	2.34 ± 0.28	2.45 ± 0.33	0.91 + 0.03	1.18 ± 0.13
1.5% ammoniated ROM	2.32 ± 0.17	–	1.16 ± 0.15	
3% ammoniated ROM	2.51 ± 0.18	2.35 ± 0.27	1.21 ± 0.04	1.58 ± 0.16
4.5% ammoniated ROM	2.27 ± 0.11	–	1.39 ± 0.28	–
6% ammoniated ROM	–	2.26 ± 0.20		1.56 ± 0.07

TABLE 13. WEIGHT OF THYROID GLANDS OF BROILER CHICKENS (EXP. 3)

Treatments	Weight, mg/100g body wt.	
	Exp. 3-A	Exp. 3-B
0% ammoniated ROM diet	6.75[b]	6.91
1.5% ammoniated ROM diet	6.80[b]	–
3% ammoniated ROM diet	9.13[ab]	7.73
4.5% ammoniated ROM diet	10.95[a]	–
6% ammoniated ROM diet	–	8.14
SEM	0.358	1.08

[a,b]: Values with different superscript in the same column are significantly different at $p < 0.01$.

ammoniation of ROM in the diet increased.

Results of Experiment 3 shows that treatment of ROM with 3% and above levels of ammonia lowers feeding value of ROM although 2 or 4 % ammoniation increased TME value and crude protein availability, and 6% ammoniation decreased potential goitrin level of ROM in Experiment 2. Keith and Bell (1984) and Bell *et al.* (1984) reported that ammonia treatment reduces availability of lysine in the meal.

It is assumed that treatments of ROM with 3% and above levels of ammonia reduced the lysine availability excessively. The fact that birds fed 1.5% ammoniated ROM diet weighed less up to 4 weeks of age but weighed more after 5 weeks of age than those fed untreated ROM diet indicates that lysine availability of ROM may have been marginally reduced by 1.5% ammoniation. It is well known that lysine requirement of the broiler chickens decreases sharply after 4 weeks of age. The ROM used in Experiment 2 and 3 came from same lot but Experiment 3 was conducted 2 years after Experiment 2. Storage of ROM under room temperature for such a long period may have influenced chemical nature of ROM. As a probable consequence, the ROM used in Experiment 3 was lower in potential goitrin but higher in isothiocyanates content than the ROM used in Experiment 2. As was in Experiment 2, ammoniation increased the level of isothiocyanates in ROM.

In earlier discussion, it was mentioned that isothiocyanates combine with ammonia to form thiourea derivatives which have a goitrogenic effect (Greer, 1950, 1962). Increase in weight of thyroid glands may be the result of formation of thiourea derivatives in the ammoniated ROM. Goh et al. (1983) showed slightly enlarged thyroid glands when the birds had been fed ammonia treated canola meal. Factors responsible for the hypertrophy of thyroid glands may also have contributed to the poor performance of the birds fed diets containing ROM treated with high level of ammonia.

Experiment 4

Table 14 shows the experimental diets which were least-cost formulated to compare SBM diet and ROM diet under practical condition. The

TABLE 14. FORMULA AND CHEMICAL COMPOSITION OF THE EXPERIMENTAL DIETS (EXP. 4)

Ingredients (%)	SBM diet	ROM diet
Corn, yellow	56.078	57.083
Soybean meal	36.453	24.359
Rapeseed meal	–	8.000
Fish meal	0.726	4.551
Animal fat	3.500	3.500
Limestone	0.545	0.397
Calcium phosphate	1.776	1.299
Salt	0.288	0.219
Methionine (45%)	0.434	0.393
Broiler premix[1]	0.200	0.200
Total (18%)	100.000	100.000
Chemical composition (%)		
ME, kcal/kg	3,000.00	3,000.00
Crude protein	21.50	21.50
Ca	0.95	0.95
P	0.47	0.48
Lysine	1.21	1.17
Methionine + Cystine	0.87	0.87

[1] Premix provides following amounts of micronutrients per kg of diet; Vit.A 10,000 IU, Vit.D_3 2,000 IU, Vit.E 8 IU, Vit.K 1 mg, Vit.B_1 0.5 mg, Vit.B_2 5 mg, Vit.B_6 0.5 mg, Vit.B_{12} 0.01 mg, Niacine 25 mg, Ca-pantothenate 10 mg, Folic acid 0.5 mg, Choline 300 mg, Ethoxyquin 1 mg, I 0.6 mg, Zn 50 mg, Mn 55 mg, Fe 40 mg, Cu 4 mg, Co 0.3 mg.

Indian ROM used in this experiment contained 0.83 mg of goitrin and 1.51 mg of isothiocyanates per g meal.

Results of the feeding trial of the broiler chickens are shown in table 15. Supplementation of Avoparcin in the ROM diets significantly ($p < 0.05$) improved weight gain at 3 weeks of age. At 4 weeks of age, however, significant differences among treatments disappeared but dose related tendency still existed both in SBM and ROM diets. Gain of the birds fed the ROM diets supplemented with Avoparcin were not significantly different from that of the birds fed SBM diet with or without Avoparcin supplementation in all ages. Feed efficiency of ROM diet was significantly ($p < 0.01$) poorer than other treatments.

Mortality, dressing percentage and weight of thyroid glands are shown in table 16. Mortality was high in birds fed ROM diet (T_3) and low in those fed SBM diet but they were not significantly different. Dressing percentage of the birds fed ROM diet (T_3) was lower than those fed other diets. Weight of thyroid glands of the birds were not significantly different among treatments.

Improvement of weight gain and feed efficiency by Avoparcin supplementation to ROM diets agree with the report of Jensen and Thomsen (1980). Extent of improvement of feed efficiency also agrees with the report of Spoerl and Kirchgessner (1978), in which supplementation of Avoparcin at the level of 7.5-15.0 ppm improved feed efficiency of broiler diet by 3.6%.

TABLE 15. CUMULATIVE WEIGHT GAIN, FEED INTAKE, FEED EFFICIENCY OF BROILER CHICKENS FED DIETS CONTAINING AVOPARCIN (EXP. 4)

Items	Weeks	T_1	T_2	T_3	T_4	T_5	SEM
	0	41.8	41.9	41.9	41.8	41.8	0.07
Weight	0-1	109.8	102.3	101.7	106.6	110.9	3.98
gain (g)	0-2	328.4	331.3	311.8	333.2	337.8	7.45
	0-3*	683.2^{ab}	698.6^{b}	657.8^{a}	696.6^{b}	702.3^{b}	9.78
	0-4	1114.2	1125.9	1101.2	1127.1	1138.3	10.59
	0-1	127.4	116.1	127.3	130.6	128.8	4.60
Feed	0-2	430.5	421.1	437.6	444.5	446.7	10.78
intake (g)	0-3	957.6	951.1	975.5	978.7	978.2	15.33
	0-4	1675.8	1671.3	1719.3	1703.9	1696.8	22.61
	0-1**	1.16^{a}	1.13^{a}	1.25^{b}	1.22^{b}	1.16^{a}	0.02
Feed	0-2**	1.31^{ab}	1.27^{a}	1.40^{c}	1.33^{b}	1.32^{b}	0.02
effi-	0-3*	1.40^{b}	1.36^{a}	1.48^{c}	1.41^{b}	1.39^{ab}	0.01
cinency	0-4**	1.50^{a}	1.48^{a}	1.56^{b}	1.51^{a}	1.49^{a}	0.01

T_1: Soybean meal diet, T_2: T_1 + Avoparcin 10 mg/kg, T_3: Rapeseed meal diet, T_4: T_3 + Avoparcin 10 mg/kg, T_5: T_3 + Avoparcin 15 mg/kg.

a,b,c: Values with different superscript in the same row are significantly different at $p < 0.01$(**), $p < 0.05$(*).

TABLE 16. MORTALITY, DRESSING PERCENTAGE AND WEIGHT OF THYROID GLANDS OF BROILER CHICKENS (EXP. 4)

Item	T_1	T_2	T_3	T_4	T_5	SEM
Mortality[1] (%)	0.00	8.00	12.00	2.00	10.00	4.05
Dressing[2] (%)	69.02	68.56	66.95	69.89	69.20	–
Thyroid glands (mg/100g body wt)	6.57	8.43	7.73	8.99	7.50	1.04

T_1: Soybean meal diet, T_2: T_1 + Avoparcin 10 mg/kg, T_3: Rapeseed meal diet, T_4: T_3 + Avoparcin 10 mg/kg, T_5: T_3 + Avoparcin 15 mg/kg,

[1] Natural death and culled from 0 to 4 wks, [2] Mean of 15 birds in each treatments.

It is interesting to note that poor dressing percentage of the birds fed ROM diet was improved by supplementation of Avoparcin. Yamamoto and Wakabayashi (1990) reported that birds fed Avoparcin supplemented diets produced more lean meat and less offals than the control birds.

Since Indian ROM was low in potential goitrin content (0.83 mg/g) and isothiocyanates are known to be less goitrogenic compared to goitrin, 8% inclusion of the Indian ROM in the broiler diet may not have influenced weight of thyroid glands. Therefore, improvement of performance of the birds in the Avoparcin supplemented diets should be explained by general growth promoting effects of antibiotics.

Overall results indicated that supplementation of Avoparcin improved productivity of the broiler chickens fed both diets but with greater response in ROM diet. According to Kirchgessner and Roth (1981), and Wakabayashi and Yamamoto (1990), Avoparcin increases amino acid availability. Therefore, the greater effects of Avoparcin supplementation in ROM diet may indicate that availability of amino acid of the ROM have been less than SBM and calculated amino acid levels of the diets have been marginally enough for the requirement of the chickens.

Conclusions

Supplementation of iodine to the diets containing high level of ROM did not improve performance of the rats. Treatment of ROM with ammonia at 2 or 4% increased metabolizable energy content and improved availability of dry matter, crude protein and crude ash. Potential goitrin level of ROM did not decrease at 2 or 4% ammoniation but considerably decreased at 6% ammoniation. On the other hand, potential isothiocyanates level of ROM increased by ammoniation.

Although the ammoniation of ROM showed beneficial effects in some of the parameters studied, ammoniation at the level of 3% and above decreased weight gain of the broiler chickens probably due to reduced lysine availability of ROM. Moreover, weight of thyroid glands increased as the level of ammoniation increased. It may not be advisable ammoniate ROM at the level of 3% and above when the treated ROM should be used in the monogastric animal diets which is marginally deficient in lysine content.

Improvement of growth rate and dressing percentage of broilers were observed when the ROM diets had been supplemented with Avoparcin. It is noteworthy that greater response from Avoparcin supplementation was shown with ROM diet than with SBM diet.

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