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The Availability of Energy and Protein, with Respect to Uric Acid, of Yellow-seeded Rapeseed Meal in Broiler Diets

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ABSTRACT : Experiments were conducted to evaluate the nutritional value of yellow-seeded rapeseed meal (YRSM). In the first experiment nutrient retention was recorded by 48 Arbor Acres-broiler chickens (28-d old) to determine AMEn (nitrogen-corrected apparent metabolizable energy), coefficient of apparent protein digestibility based on ileal digesta nitrogen, excreta nitrogen and uric acid nitrogen. The second experiment was carried out with 304 Arbor Acres-broiler chickens to compare effects of SBM (soybean meal) and YRSM on performance, carcass and digestive tract status. In the control treatment, SBM was replaced by graded levels of YRSM at 15, 22.5 and 30% of diet. Digestibility of YRSM protein was significantly lower ($p<0.001$) than SBM protein. The protein digestibility based on ileal measurement was significantly higher ($p<0.001$) than protein digestibility from excreta samples. There was no significant difference ($p>0.001$) between ileal and excreta digestibility of protein based on uric acid. AMEn as a fraction of gross energy was 0.54 in SBM and 0.45 in YRSM. With the exception of 30% YRSM, other YRSM treatments resulted in major effects on length and weight of the gastrointestinal tract. The results of this study have shown no adverse effect on performance as well as protein digestibility and energy value in response to replacement of SBM by YRSM with the exception of 22.5 and 30% YRSM. (**Key Words :** Yellow-seeded Rapeseed Meal, AMEn, Protein Digestibility, Uric Acid, Broiler)

INTRODUCTION

Poultry diets typically contain from 15 to 20% CP per kg (Perttila et al., 2002). Soybean products are commonly used as protein sources in poultry diets. Rapeseed is used extensively for oil production, therefore the nutritional value of the meal should be ascertained for livestock. Interest in reduction of nitrogen excretion and lowering feed cost has increased interest in by-products and alternative protein sources. Protein digestibilities of these sources are often lower compared to soybean meal. Rapeseed meal (the oil-free residue of low glucosinolates and low erucic acid) has been known especially as an ingredient in poultry diets (Newkirk et al., 2003), but the nutritional value of yellow-seeded rapeseed meal has not been extensively studied previously. All dietary components are important in poultry feed formulation, but critical attention should be paid to the dietary protein. Nitrogen intake may be influenced by metabolizable energy and consequently excreta nitrogen. For these reasons and the vital role energy as a more important regulator of feed intake than protein, determination of metabolizable energy and protein digestibility is important for by-products. Therefore, the objective of the current study was focused on the estimation of protein and energy availability based on an inert indigestible marker. Apparent protein digestibility can be calculated using total amino acids or nitrogen content of ileal digesta, but this method is expensive and time-consuming. The combined excretion of urine and feces in poultry complicates the evaluation of the digestibility of protein. Nearly 88% of the total urinary nitrogen is contained in uric acid (Krogdahl and Dalsgard, 1981). Consequently, apparent protein digestibility may be estimated by subtracting the nitrogen of uric acid from total excreta nitrogen.

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MATERIALS AND METHODS

Nutrient retention

Nitrogen-corrected apparent metabolizable energy was determined according to the method of Newkirk et al. (2003) using 48 broiler cockerels raised to 28 d of age. Two birds were randomly allocated per cage and the cages (experimental units) were randomly assigned to one of three dietary treatments. The basal diet contained corn and

Table 1. Composition and calculated nutrient content of diets used in the digestibility study (%)

Ingredient	Basal diet	SBM diet	YRSM diet
Corn	62.50	35.45	35.45
Soybean meal	-	40.00	-
YRSM	23.65	13.00	53.00
Fish meal	4.90	2.70	2.70
Oil	4.55	4.55	4.55
Oyster shell	1.45	1.45	1.45
Dicalcium phosphate	1.55	1.55	1.55
Salt	0.40	0.40	0.40
Chromic oxide	0.50	0.50	0.50
Premix*	0.50	0.50	0.50
Calculated nutrient content (as-fed basis)			
ME (MJ/kg)	12.88	11.65	8.66
Protein	15.63	25.49	21.09
Lysine	0.82	1.74	1.23
Met+Cys.	0.36	0.49	0.49
Ca	1.25	1.18	1.35
Available p	0.56	0.53	0.56

* Supplied per kg of diet: 100 mg Zinc, 100 mg manganese, 50 mg iron, 0.3 mg selenium, 10 mg copper, 1 mg iodine, 9,000 IU vitamin A, 2,000 IU vitamin D_3, 18 IU vitamin E, 2 mg K_3, 1.8 mg thiamine, 6.6 mg riboflavin, 30 mg niacin, 10 mg pantothenic acid, 3 mg pyridoxine, 1 mg folic acid, 0.1 mg biotin, 250 mg choline.

soybean meal as the major ingredients. The test ingredient, soybean meal and yellow-seeded rapeseed meal, was included in the basal diet at a level of 40%. The diets were fed to the birds for 7d. Chromic oxide was included in all diets as an indigestible marker. The basal and test diets are presented in Table 1. Feed and water were offered *ad libitum* at all times. Excreta were collected daily for the last 3 d and frozen upon collection. The excreta samples from each replicate were pooled on the final day and dried in an oven at 50°C prior to grinding and chemical analysis. Upon final collection, the birds were euthanased and the contents of the distal ileum (Meckel's diverticulum to a point 3 cm proximal to the ileo-caecal junction) were collected and freeze-dried. Chromic oxide was measured according to the method of Fenton and Fenton (1979). The dietary AMEn was multiplied by a factor of 1.044 as described by Newkirk et al. (2003) to compensate for the test and basal diets containing 4.4% of premix (limestone, dicalcium phosphate, salt, vitamin premix and chromic oxide) per 95.6% of macro ingredients. Therefore, AMEn of meals was calculated as: AMEn of meal = ((Test diet AMEn-Basal diet AMEn×0.6)/4)×10. Ileal protein digestibility was determined as described by Ten Doeschate et al. (1993) as follow:

$$DC_{diet} = 1 - \left[\left(\frac{M_{diet}}{M_{i,e}} \right) \times \left(\frac{C_{i,e}}{C_{diet}} \right) \right]$$

Where DC_{diet}, digestibility coefficient of protein in diet; M_{diet}, marker concentration in diet; $M_{i,e}$ marker concentration in ileal digesta (i) or excreta (e); C_{diet}, concentration of protein in diet; $C_{i,e}$ concentration of protein in ileal digesta (i) or excreta (e).

$$DC_{meal} = \left[\frac{DC_{test} \times C_{test} - DC_{basal} \times C_{basal} \times 0.6}{C_{test} - C_{basal} \times 0.6} \right]$$

Where DC_{meal}, digestibility coefficient of protein in the meal; DC_{basal}, digestibility coefficient of protein in the basal diet; DC_{test}, digestibility coefficient of protein in the test diet; C_{basal}, concentration of protein in the basal diet; C_{test}, the concentration of protein in the test diet.

The excreta digestibility of protein based on uric acid was calculated as follows:

The excreta samples of birds fed basal and test diets were analyzed for uric acid content (Marquardt, 1983). The protein content of excreta samples was corrected based on uric acid as: (% nitrogen of excreta sample-% nitrogen of uric acid in excreta sample)×6.25.

With these corrected data, excreta digestibility of protein based on uric acid was calculated by the procedure of Ten Doeschate et al. (1993).

Performance

The nutritional value of YRSM was further evaluated in feeding trials with broiler chickens. Three hundreds and four 10-d old unsexed Arbor Acres Chickens were reared under controlled conditions of heating and light with a prestarter diet (13.39 Mj metabolizable energy and 23% crude protein per kg of diet) (Noy and Sklan, 1999) and then ranked in order of weight. The mean weight of 167 g was selected and chickens were sub-divided into 4 groups of ascending weight. From each subdivision, chickens were chosen at random and allocated to one of four treatments. There were four replications per treatment and 19 birds per replication (pen). Treatments were formulated to meet NRC (1994) requirements (Table 2). The first treatment was based on corn-soybean meal as a control diet and the other three treatments were based on corn but soybean meal was replaced by graded levels of YRSM at 15, 22.5 and 30% of diet. Chickens were housed in their pens based on their similar average weight. Food and water were offered *ad libitum*. This trial was conducted between days 11 to 21 and 22 to 42 of life. Prior to weighing on d 42, the birds were fasted for 4 h. Growth rate and feed intake of each pen were recorded on d 21 and at the end of the experiment.

Carcass and intestinal measurements

The carcass and intestinal characteristics were measured on d 21 and at the end of the trial. Two birds from each pen were euthanased. Breast meat, thigh, abdominal fat, heart and gastrointestinal segments were removed and weighed.

Table 2. Composition and calculated nutrient content of diets used in the performance study (%)

Ingredient	Starter				Grower			
	Control	15.0	22.5	30.0	Control	15.0	22.5	30.0
Corn	63.41	57.11	53.96	50.82	69.36	61.17	56.86	52.00
Soybean meal	30.00	19.53	14.29	9.03	23.55	17.76	13.95	10.12
YRSM	-	15.00	22.50	30.00	-	15.00	22.50	30.00
Fish meal	3.00	3.00	3.00	3.00	1.00	1.00	1.00	1.00
Oil	0.25	2.30	3.32	4.34	-	1.60	2.90	4.20
Oyster shell	1.11	0.95	0.88	0.80	1.37	0.91	0.83	0.75
Dicalcium phosphate	1.27	1.21	1.18	1.16	2.06	1.23	1.20	1.15
Salt	0.32	0.34	0.35	0.35	0.40	0.28	0.29	0.29
DL-methionine	0.14	0.07	0.03	-	0.05	0.02	-	-
Premix*	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Calculated nutrient content (as- fed basis)								
ME (MJ/kg)	12.13	12.13	12.13	12.13	12.13	12.14	12.15	12.15
Protein	21.0	21.0	21.0	21.0	18.4	18.4	18.4	18.4
Crude fiber	3.60	4.00	4.96	5.40	3.60	4.00	4.96	5.40
Lysine	1.17	1.15	1.13	1.11	0.98	0.93	0.91	0.91
Met+cys.	0.84	0.84	0.84	0.85	0.65	0.69	0.70	0.76
Ca	0.91	0.91	0.90	0.91	0.85	0.81	0.81	0.81
Available p	0.45	0.46	0.45	0.45	0.42	0.40	0.41	0.41

* Supplied per kg of diet: 100 mg zinc, 100 mg manganese, 50 mg iron, 0.3 mg selenium, 10 mg copper, 1 mg iodine, 9,000 IU vitamin A, 2,000 IU vitamin D_3, 18 IU vitamin E, 2 mg K_3, 1.8 mg thiamine, 6.6 mg riboflavin, 30 mg niacin, 10 mg pantothenic acid, 3 mg pyridoxine, 1 mg folic acid, 0.1 mg biotin, 250 mg choline.

Table 3. Chemical composition of meals on as-fed basis (%)

Meals	DM	GE*	CP	CF	EE
SBM	90.00	17.41	43.75	7.40	4.83
YRSM	91.30	19.38	31.00	13.70	6.60

* Gross energy (MJ/kg).

The weight and length of the gastrointestinal sections were expressed as a proportion of body weight.

Statistical analysis

All experiments were set up as completely randomized designs. All data were analyzed by one-way analysis of variance (ANOVA) using the General Linear Model (GLM) procedure (SAS Institute, 1989). Variables with significant F-tests ($p<0.05$) were compared using Duncan's multiple range test.

RSULTS

Nutrient retention

The chemical compositions of SBM and YRSM are shown in Table 3 expressed on an as-fed basis. The nutrient retention of meals is presented in Table 4. Digestibilty of YRSM protein was significantly lower ($p<0.001$) than SBM protein. The ileal digestibility of protein was significantly higher ($p<0.001$) than the excreta digestibility of protein. The excreta digestibility of protein was significantly lower ($p<0.001$) than the excreta digestibility of protein based on uric acid. The AMEn of YRSM was significantly lower ($p<0.05$) than AMEn of SBM.

Performance

The results of performance of broiler chickens are listed in Table 5. Dietary treatments did not affect ($p>0.05$) broiler feed intake to 21 d of age. However feed intake was highest for birds fed with the SBM diet in comparison to YRSM. The growth rate of birds fed the 30% YRSM diet was significantly lower ($p<0.05$) than other treatments at 21 d of age. The inclusion of 30% YRSM in the diet of chickens resulted in a significant decrease ($p<0.05$) in feed intake at 42 d of age as compared to the control diet. The inclusion of 22.5 and 30% YRSM in the diet resulted in a significant decrease ($p<0.01$) in the growth rate of chickens as compared to those fed the control diet. Feed to gain ratio of birds fed 30% YRSM was inferior ($p<0.01$) to birds fed the control diet during the whole experiment.

Carcass and intestinal measurements

With the exception of abdominal fat ($p<0.05$), other

Table 4. Protein digestibility and energy value in soybean meal and yellow-seeded rapeseed meal

Parameters	SBM			YRSM			SEM	p-value
	Ileal	Based on U.A[1]	Excreta	Ileal	Based on U.A[1]	Excreta		
Protein digestibility %	83.9 [a]	80.76 [a]	75.00 [b]	79.20 [b]	74.80 [b]	65.30 [c]	1.49	***
AMEn (MJ/kg)	-		9.33 [a]	-		8.71 [b]	20	*

Values within a row with unlike superscripts differ significantly, *** $p<0.001$, * $p<0.05$. SEM = Standard error of mean.

[1] Excreta digestibility of protein based on uric acid.

Table 5. Effect of different levels of YRSM on performance of broilers chickens in the periods from day 10 to 21 and day 22 to 42 of age

Diets	Feed intake (g)		Growth rate (g)		FCR	
	10-21	22-42	10-21	22-42	10-21	22-42
Control	645	2,885[a]	366[a]	1,451[a]	1.76[b]	1.98[b]
YRSM 15 (%)	626	2,788[ab]	351[a]	1,385[ab]	1.78[b]	1.99[b]
YRSM 22.5 (%)	614	2,713[ab]	339[a]	1,310[b]	1.80[b]	2.06[ab]
YRSM 30 (%)	600	2,556[b]	305[b]	1,188[c]	1.96[a]	2.14[a]
SEM	13	68	11	35	0.025	0.026
p-value	n.s	*	*	**	**	**

Values within a column with unlike superscripts differ significantly, * p<0.05, ** p<0.01.
SEM = Standard error of mean.

Table 6. Carcass composition, weight (g) and length (cm) of internal organs and intestines per 100 g of body weight from 22 to 42 days of age

Diets	Live weight	Breast wt	Thigh wt	Fat wt	Heart wt	Small gut wt	Gizzard wt	Liver wt	Pancreas wt	Gut L	Caeca L
Control	1,984.7[a]	20.75[a]	18.73[a]	3.63[a]	0.61	3.65[a]	3.32	3.40[a]	0.36	8.17[ab]	0.79[ab]
YRSM 15 (%)	1,903.3[ab]	19.37[ab]	18.71[a]	2.91[ab]	0.62	3.70[a]	3.40	3.40[a]	0.35	8.35[a]	0.84[a]
YRSM 22.5 (%)	1,817.0[b]	19.53[ab]	18.45[a]	2.52[b]	0.62	3.69[a]	3.38	3.47[ab]	0.33	8.40[a]	0.84[a]
YRSM 30 (%)	1,660.3[c]	18.28[b]	17.48[b]	2.45[b]	0.65	3.56[b]	3.04	3.51[b]	0.32	7.97[b]	0.75[b]
SEM	38.2	0.45	0.31	0.27	0.02	0.03	0.09	0.03	0.01	0.11	0.02
p-value	**	**	*	*	ns	*	0.06	*	ns	*	*

Values within a column with unlike superscripts differ significantly, * p<0.05, ** p<0.01.
Wt = Weight, L = Length. SEM = Standard error of mean.

estimates of carcass weight and digestive tract were not affected by dietary treatments at 21 d of age. The effects of dietary treatments on carcass composition, weight and length of digestive organs relative to live body weight at 42 d of age are listed in Table 6.

DISCUSSION

The AMEn of SBM is consistent with the value published by NRC (1994). Little information is available on the AMEn of YRSM, but the present results indicate that AMEn of YRSM is significantly lower than SBM which is in agreement with data presented by Newkirk et al. (1997). The AMEn of YRSM in the current study was 8.71 MJ/kg. The AMEn value of rapeseed meal reported by Clandinin and Robblee (1983), Newkirk et al. (1997) and Newkirk et al. (2003) was 9.37±0.59, 8.80±1.27 and 9.46±0.43 MJ/kg, respectively. This variation may be related to other factors that influence metabolizable energy such as glucosinolates, tannin, phytic acid (Qiao and Classen, 2003), protein and oil content of the meal (Bell, 1993), variety and quality of seed (Slominski et al., 1999), availability of protein and amino acid (Zhang et al., 1994), level of feed intake (Yap et al., 1997; Kadim et al., 2002) and age of birds (Ten Doeschate et al., 1993). Therefore, these factors may be partly responsible for AMEn variation.

The lower protein digestibility of YRSM may be related to higher fibre content than SBM. This finding implies fibre impedes protein utilisation (Simbaya et al., 1996). This mechanism is not clear, but the indigestible protein fraction in the meal may be bound to, or encapsulated by fibrous components (Jensen et el., 1995). The results of excreta digestibility of protein based on uric acid clearly indicated this method is not only much easier and cheaper to perform but also yields similar values in comparison to ileal digestibility of protein.

The carcass and digestive tract measurements were not affected by dietary treatments at 21 days of age; that may be explained by the short duration of the performance experiment.

In the current study, the decrease in breast meat with inclusion of YRSM in the diets is consistent with results founded by Perttila et al. (2002). The liver enlargement is related to hydrolysis products of glucosinolates, especially nitriles (Thomke et al., 1998; Qiao and classen, 2003). The decrease in proportion of abdominal fat is due to smaller carcass and bones, it has been suggested in previous studies that the skeleton may be an important site for lipogenesis in the chicken (Nir and Lin, 1982). Form and function of gastrointestinal tract are affected by fiber content of the diet. On the other hand, inclusion of sawdust in a Japanese quail ration increased gizzard weight and length of small intestine and caeca (Savory, 1976). Therefore, increased caecal length, gizzard and small intestine weights are probably related to YRSM fibre, but decreased estimates for these parameters in birds fed 30% YRSM diet do not conform to this explanation and may be related to other factors. These results are consistent with results presented by Shires et al. (1987) who reported that canola meal diet is associated with an increase in the dry weights of gizzard and jujenum relative to body weight as well as an increase in the length of jejunum and ileum.

IMPLICATION

In conclusion, the lower availability of energy and protein in yellow-seeded rapeseed meal (YRSM at 22.5 and 30%) in comparison to SBM along with antinutritional factors of YRSM, such as glucosinolate, phytic acid, uric acid, tannins and dietary fiber, may be responsible for poorer performance and a detrimental effect on broiler chickens. This study provided evidence that there were no significant differences between ileal digestibility of protein and excreta digestibility of protein based on uric acid. Finally, this study showed that segments of gastrointestinal tract vary in length and weight with dietary composition.

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