Iran Agricultural Research (2016) **35(2)** 41-46

Shiraz University

Determination of standardized prececal protein digestibility of canola meal in British United Turkeys Big 6 at different ages using multiple linear regression procedure

M.R. Rezvani*, A. Akhlaghi, F. Saemi, M.M. Ommati, M. Dadpasand, H. Atashi

Department of Animal Science, College of Agriculture, Shiraz University, Shiraz, I. R. Iran

*Corresponding Author: rezvani@shirazu.ac.ir

ARTICLE INFO

***Article history*:**
Received **29 September 2014**
Accepted **21 February 2016**
Available online **17 July 2016**

***Keywords*:**
Standardized prececal protein digestibility
Multiple linear regression
Canola meal
British United Turkeys Big 6

ABSTRACT- Ninety six 2-week-old British United Turkeys (BUT) Big 6 were assigned to 2 groups (4 replicates of 12 birds each). One basal diet and another one in which 20% canola meal replaced the corn starch in the basal diet were prepared. At 9, 16 and 21 wk of age, four birds from each pen slaughtered for digesta collection. The last two-third segment of the intestine, between the Meckel's diverticulum and about 2 cm anterior to the ileo-ceca-colonic junction, was excised. The diets and digesta were analyzed for dry matter, crude protein, and chromic oxide content. The standardized prececal protein digestibility of canola meal was calculated using multiple linear regression procedure. The standardized prececal protein digestibility of canola meal at 21 wk of age was significantly lower as compared with that of 9 wk of age; the relative weight of digestive organs also decreased significantly with increasing age ($P< 0.05$). By using multiple linear regression which accounted for the endogenous nitrogen losses, we showed that standardized prececal protein digestibility was also influenced by the age.

INTRODUCTION

Diet formulation is a vital issue in poultry production. Although, the total nutrient components is a very important issue in poultry industry, the digestibility of the individual nutrient is of greater importance in terms of meeting higher performance and lower environmental nitrogen loss in contemporary production systems. British United Turkeys (BUT) Big 6 have recently become popular among producers, mainly because of higher growth rate and performance compared to other meat birds, and research on feed digestibility is scarce in this turkey.

Much data have been published (Payne et al., 1971; Nordheim and Coon, 1984; Sibbald, 1986) on feed digestibility in birds, using current methods of digestibility measurements, but these methods have been criticized for not accounting for the endogenous nitrogen loss contributed by the posterior part of the hind gut, and also being more time-consuming (Sibbald, 1987; Sauer et al., 2000; Lemme et al., 2004; Ravindran et al., 2004). Such limitations of the current methods can be overcome through prececal or total tract digestibility measurements using cecectomized birds (Rezvani et al., 2008a; Rezvani et al., 2008b). To correct for the endogenous losses of the nutrients, the losses are usually estimated by using various techniques, although the estimates can vary according to the method used (Perez et al., 1993; Siriwan et al., 1993; Donkoh and Moughan, 1999; Jansman et al., 2002). Therefore, methods which do not require separate determination of endogenous losses would be of great value in feed evaluation. This can be achieved by using multiple linear regression (MLR) procedure, and using at least two levels of each ingredient, thus eliminating the need for using another group of birds for estimating the endogenous losses (Short et al., 1999; Rodehutscord et al., 2004; Kluth et al., 2005; Rezvani et al., 2012).

Published data on the effect of age on nitrogen digestibility in poultry (Kadim et al., 2002; Ravindran et al., 2004; Huang et al., 2005; Adedokun et al., 2007a; Rezvani et al., 2007) are not consistent, mainly due to incorrect sampling site and/or the method applied for correcting the endogenous losses. To the best of our knowledge, the MLR approach has not yet been used to study the effect of age on standardized prececal protein digestibility in BUT Big 6. Therefore, the present study aimed at determining the effect of age on standardized prececal protein digestibility using the MLR approach. Two levels of canola meal (as a non-conventional feed for BUT Big 6) were used to measure the standardized prececal protein digestibility in three age groups. Canola meal contains a high protein concentration with high methionine digestibility in both layers and meat-type poultry (Kluth et al., 2005; Rezvani et al., 2008a; Rezvani et al., 2012).

MATERIALS AND METHODS

Birds and Experimental Treatments

One hundred and fifty five-day-old male BUT Big 6 were obtained (Aviagen® Co., Grantham Hatchery, Grantham, UK) and reared according to the company's guidelines at the Experimental Research Station of Animal Science, College of Agriculture, Shiraz University, Shiraz, Iran (18L:6D photoschedule; 20 lx). The rearing temperature was set at 32˚C during the first wk of age and then reduced by 2.8˚C per wk, reaching to a final temperature of 20˚C. At the second wk of age, 96 birds were randomly selected and assigned to 8 floor pens (2 treatment groups with 4 replicates of 12 birds each), in a completely randomized design. The pens were equipped with a hanging feeder and a bell drinker. The first group, received a basal diet (NRC, 1994) comprising mainly corn grain, corn starch and wheat gluten. The second group was fed with a diet containing 20% canola meal substituted for corn starch in the basal diet, so that the differences in crude protein (CP) content of the diets could be attributed to the canola meal (Table 1). Analyzed chemical composition of the canola meal was shown in Table 2. Chromic oxide (Cr_2O_3) was added to the diets (0.5%) as a marker for measuring the standardized prececal protein digestibility. The diets were fed as mash form, prepared by using a hammer mill (3 mm screen). The diets were fed to the birds only one wk before the slaughtering time at different ages. At other times, the birds were fed the conventional turkey diets which were prepared from The Rad Ard Pars Company, Shiraz, Iran.

Table 1. Ingredients and chemical composition of basal diets and diets with 20% of canola meal (CM) substituted for corn starch in the basal diet

Age (wk)	9		16		21	
Diets	Basal diet	CM diet	Basal diet	CM diet	Basal diet	CM diet
Ingredients **(%)**						
Rice hull	15.1	15.1	15.2	15.2	15.1	15.1
Corn	36.7	36.7	45.0	45.0	45.9	45.9
Wheat gluten	19.0	19.0	14.7	14.7	12.9	12.9
Corn starch	20.0	0	20.0	0	20.0	0
CM (CP = 36 %)	0	20.0	0	20.0	0	20.0
Soybean oil	0	0	0	0	2.45	2.45
Cr_2O_3	0.050	0.050	0.050	0.050	0.050	0.050
Dicalcium phosphate	3.67	3.67	1.61	1.61	1.56	1.56
NaCl	0.260	0.260	Basal diet	CM diet	Basal diet	CM diet
$CaCO_3$	3.55	3.55				
Premix[1]	0.500	0.500	15.2	15.2	15.1	15.1
L- Lysine HCl	1.00	1.00	45.0	45.0	45.9	45.9
DL-Methionine	0.020	0.020	14.7	14.7	12.9	12.9
L- Threonine	0.150	0.150	20.0	0	20.0	0
Calculated analysis (DM basis)						
Metabolizable energy (kcal/kg)	2850	2500	3000	2670	3200	2840
Crude protein	20.9	28.1	18.0	25.1	16.5	23.6
Ca (%)	2.42	2.56	1.22	1.36	0.772	0.906
Available P (%)	0.766	0.840	0.368	0.442	0.358	0.432
Methionine	0.382	0.544	0.343	0.505	0.288	0.450
Lysine	1.25	1.68	0.995	1.43	0.822	1.26

[1]Provided per kg: vitamin A, 7350 IU; vitamin D_3, 2200 ICU; vitamin E, 8 IU; riboflavin, 5.5 mg; d-pantothenic acid, 13.0 mg; niacin, 36 mg; choline, 500 mg; vitamin B_{12}, 0.02 mg; menadione, 2 mg; folic acid, 0.5 mg; thiamine mononitrate, 1.0 mg; pyridoxine, 2.2 mg; d-biotin, 0.05 mg; Cu, 6.0 mg; Fe, 54.8 mg; I, 1.0 mg; Mn, 65.3 mg; Se, 0.3 mg; Zn, 55.0 mg.

Table 2. Analyzed chemical composition of the canola meal (percent, on dry matter basis unless stated otherwise)

Dry matter	Crude protein	Ether Extract	Ash	Crude fibre	Neutral detergent fiber	Calcium	Phosphorus	Total Glucosinolates (mmol/kg DM)
88.7	38.7	3.72	8.09	15.6	26.5	0.830	1.29	8.98

Sampling and Data

Body weight and feed intake were recorded weekly on a pen basis. Average daily gain, feed intake, and feed conversion ratio were also calculated. During the rearing period, 4 birds per pen were slaughtered at 9, 16, and 21 wk of age. Digesta were obtained by flushing the last two third segments of the intestine, between the Meckel's diverticulum and 2 cm anterior to the ileo-ceca-colonic junction, using distilled water (Rezvani et al., 2008b). The digests were then frozen at -20°C immediately, vacuum-dried, and grounded. The gizzard, proventriculus, liver, intestine and pancreas were dissected out, and weighed for calculation of the relative weight of the organs.

The dried digesta and diets were analyzed, in triplicate, for dry matter (DM) and crude protein (CP) according to AOAC procedures (1990). The content of Cr_2O_3 was determined in the diets and digesta using an atomic absorption spectrophotometer (Shimadzu, AA 670, Tokyo, Japan) according to Williams et al. (1962). Prececal protein digestibility of the diets was calculated using the following equation:

Digestibility (%) = $100 - 100 \times [(Cr_2O_{3Diet} \times CP_{Digesta})/(Cr_2O_{3Digesta} \times CP_{Diet})]$ in which, Cr_2O_{3Diet} and $Cr_2O_{3Digesta}$ represent concentrations of Cr_2O_3 in the diet and digesta samples (g/kg), respectively, and CP_{Diet} and $CP_{Digesta}$ stand for the concentrations of CP in the diet and digesta samples (g/kg), respectively.

Statistical Analysis

Data were analyzed using the GLM procedure of SAS (2004). Multiple linear regression analysis, as suggested by Kluth et al. (2005), was used to determine the standardized prececal protein digestibility, where digested protein was regressed on the protein intake. As basal endogenous loss was included through the intercept (α), no correction was made for basal endogenous losses. The following model was applied to determine the digestibility of canola meal protein (Rezvani et al., 2008b):

$y_{bsij} = \alpha + \beta_b X_b + \beta_{si} X_{si} + e_{bsij}$, where, y_{bsij} = the amount of daily digested protein from canola meal-containing diet (mg/d), α = intercept, β_b = digestibility of protein originating from the basal diet, X_b = daily intake of protein originating from the basal diet (mg/d), β_{si} = digestibility of protein originating from canola meal, X_{si} = daily intake of protein originating from canola meal, and e_{bsij} = error term with mean 0 and normal distribution. The treatment means were compared using the Duncan's multiple range test at the significance level of 0.05.

RESULTS AND DISCUSSION

The effect of age on the digestibility of canola meal protein, body weight, feed conversion ratio, and relative weights of digestive organs are summarized in Table 3. The digestibility of canola meal protein (%) was 83.2 ± 12.1, 77.9 ± 15.6, and 70.3 ± 17.3, at 9, 16, and 21 wk of age, respectively, with a significant difference between age 9 and 21wk ($P< 0.05$; Fig. 1). A linear increasing trend was found for the feed conversion ratio with increasing age. The analysis of carcass constituents showed a significant decreasing trend ($P< 0.05$) in the relative weights of the digestive organs in the birds fed by canola meal at different ages.

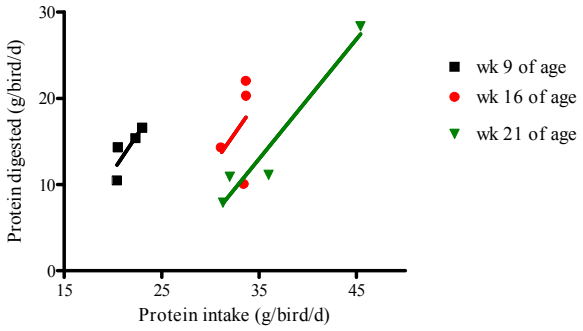

Fig. 1. The standardized prececal protein digestibility of canola meal in BUT Big 6 at different ages calculated using multiple linear regression approach

Table 3. The effect of age on standardized prececal protein digestibility of canola meal, body weight, feed conversion ratio, and relative weight of digestive organs in British United Turkeys Big 6

Age (wk)	9	16	21	*P*-value
Protein digestibility (%)	83.2 ± 12.1[a]	77.9 ± 15.6[ab]	70.3 ± 17.3[b]	< 0.0001
Feed intake (kg/bird)	10.3 ± 0.378[c]	27.3 ± 0.378[b]	48.1 ± 0.378[a]	< 0.0001
Body weight (kg/bird)	4.17 ± 0.191[c]	11.1 ± 0.191[b]	18.0± 0.192[a]	< 0.0001
Feed conversion ratio	2.47 ± 0.034[b]	2.46 ± 0.035[b]	2.67 ± 0.035[a]	< 0.0003
Relative weight **(%)**[1]				
Gizzard	2.7 ± 0.046[a]	1.78 ± 0.045[b]	1.04 ± 0.047[c]	< 0.0001
Proventriculus	0.264 ± 0.005[a]	0.176 ± 0.005[b]	0.083 ± 0.005[c]	< 0.0001
Liver	1.60 ± 0.034[a]	1.32 ± 0.033[b]	0.692 ± 0.034[c]	< 0.0001
Intestine	2.48 ± 0.057[a]	2.04 ± 0.056[b]	1.51 ± 0.058[c]	< 0.0001
Pancreas	0.183 ± 0.005[a]	0.104 ± 0.005[b]	0.059 ± 0.005[c]	< 0.0001

[a-c] Means in the same row without a common superscript differ significantly ($P< 0.05$).

[1]As a percentage of live weight

The main aim of this study was to investigate the effect of age on the standardized prececal protein digestibility of canola meal using multiple linear regression approach. The results showed that the effect of birds' age on the digestibility was significant ($P< 0.05$). Huang et al. (2005) showed that age significantly affected the CP apparent digestibility. Tarvid (1995) also found that age had a significant effect on the digestion and absorption of dietary protein in broiler chickens. Zuprizal and Chagneau (1992) reported a decreasing trend for CP and amino acid digestibility of canola meal as the birds' age increased. It might be assumed that if the effect of the endogenous components was not considered at different ages, the apparent digestibility measurements would be adversely affected, so the higher endogenous loss will result in lower apparent digestibility.

In contrast to this study, Adedokun et al. (2007b) found no differences in the apparent ileal digestibility of a number of amino acids between 5 and 21 d of age in turkey pullets. Rezvani et al. (2007) reported that apparent prececal digestibility of most amino acids at age 57 wk was higher than those of 27 or 40 wk in cecectomized laying hens. However, the digestibility measurements in the present study were corrected for the endogenous losses using the regression model procedure which is standardized and therefore the measurements are more accurate. The relative weights of gizzard, proventriculus, liver, intestine and pancreas were significantly lower ($P< 0.05$) at older ages. The decreased relative weights of the digestive organs (which contribute to the endogenous nitrogen losses) at older ages could be associated with lower endogenous nitrogen losses. Not considering this fact might result in higher apparent protein digestibility at older ages as reported previously (Rezvani et al., 2007). By applying MLR, the interference of the endogenous losses on protein digestibility is corrected, thereby resulting in lower standardized protein digestibility at older ages.

This study showed that using the multiple regression method for determining the standardized prececal protein digestibility in canola meal at 3 different ages reflected the effect of age on protein digestibility. Investigation of the standardized prececal protein digestibility of canola meal and the effect of age using cecectomized turkeys would reduce the standard errors as reported previously (Rezvani et al., 2008a; Rezvani et al., 2012). Furthermore, the digestibility of amino acids rather than protein in cecectomized turkeys would be a more accurate measure of feed protein quality in formulating the diets more economically.

ACKNOWLEDGMENTS

The authors wish to thank M. Ektefaee, A. Abbasian Najafabadi, and other students in the Department of Animal Science, Shiraz University for their help during rearing of the birds. Mr. E. Rohani and R. Frozan (Rad Ard Pars Co., Shiraz, Iran) are also acknowledged for providing the feed ingredients.

REFERENCES

Aguilera, J.F., Prieto, E., Molina, E., & Lachica, M. (1988). A micromethod for routine determination of chromic dioxide in nutrition studies. *Analusis*, 16, 454-457.

Adedokun, S.A., Parsons, C.M., Lilburn, M.S., Adeola, O., & Applegate, T.J. (2007a). Comparison of ileal endogenous amino acid flows in broiler chicks and turkey pullets. *Poultry Science*, 86, 1682-1689.

Adedokun, S.A., Parsons, C.M., Lilburn, M.S., Adeola, O., & Applegate, T.J. (2007b). Standardised ileal amino acid digestibility of meat and bone meal from different sources in broiler chicks and turkey pullets with a nitrogen-free or casein diet. *Poultry Science*, 86, 2598-2607.

AOAC (1990). Official Methods of Analysis. Association of Official Analytical Chemists. 15th edition. Washington, DC.

Donkoh, A., & Moughan, P.J. (1999). Endogenous ileal nitrogen and amino acid flows in the growing pig receiving a protein-free diet and diets containing enzymatically hydrolyzed casein or graded levels of meat and bone meal. *Animal Science*, 68, 511-518.

Huang, K.H., Ravindran, V., Li, X., & Bryden, W.L. (2005). Influence of age on the apparent ileal amino acid digestibility of feed ingredients for broiler chickens. *British Poultry Science*, 46, 236-245.

Jansman, A.J.M., Smink, W., VanLeeuwen, P., & Rademacher, M. (2002). Evaluation through literature data of the amount and amino acid composition of basal endogenous crude protein at the terminal ileum of pigs. *Animal Feed Science and Technology*, 98, 49-60.

Kadim, T.I., Moughan, P.J., & Ravindran, V. (2002). Ileal amino acid digestibility assay for the growing meat chicken: Comparison of ileal and excreta amino acid digestibility in the chicken. *British Poultry Science*, 44, 588-597.

Kluth, H., Mantel, M., Elwert, C., & Rodehutscord, M. (2005). Variation in prececal amino acid and energy digestibility between pea (*Pisum sativum*) cultivars determined using a linear regression approach. *British Poultry Science*, 46, 325-332.

Lemme, A., Ravindran, V., & Bryden, W.L. (2004). Ileal digestibility of amino acid in feed ingredients for broilers. *World's Poultry Science Journal*, 60, 423-437.

NRC (1994). Nutrient Requirements of Poultry. 9th rev. ed. National Research Council, National Academy Press, Washington, DC.

Nordheim, J.P., & Coon, C.N. (1984). A comparison of four methods for determining available lysine in animal protein meal. *Poultry Science*, 63, 1040-1051.

Payne, W.L., Kifer, R.R., Snider, D.G., & Combs, G.F. (1971). Studies of protein digestion in chicken. 1. Investigation of apparent amino acid digestibility of fish meal protein using cecectomised, adult male chickens. *Poultry Science*, 50: 143-150.

Perez, L., FernandezFigarez, I., Nieto, R., Aguilera, F., & Prieto, C. (1993). Amino acid ileal digestibility of some

grain legume seeds in growing chickens. *Animal Production*, 56, 261-267.

Ravindran, V., Hew, L.I., Ravindran, G., & Bryden, W.L. (2004). Endogenous amino acid flow in the ileum: Quantification using three techniques. *British Journal of Nutrition*, 92, 217-223.

Rezvani, M., Kluth, H., Woitow, G., & Rodehutscord, M. (2007). Studies on the effect of age and caecectomy on amino acid excretion and digestibility in laying hens. *European Poultry Science*, 71, 241-246.

Rezvani, M., Kluth, H., & Rodehutscord, M. (2008a). Comparison of amino acid digestibility determined prececally or based on total excretion of cecectomized laying hens. *Poultry Science*, 87, 2311-2319.

Rezvani, M., Kluth, H., Elwert, C., & Rodehutscord, M. (2008b). Effect of ileum segment and protein sources on net disappearance of crude protein and amino acids in laying hens. *British Poultry Science*, 49, 28-36.

Rezvani, M., Kluth, H., Bulang, M., & Rodehutscord, M. (2012). Variation in amino acid digestibility of rapeseed meal studied in caecectomised laying hens and relationship with chemical constituents. *British Poultry Science*, 53: 665-674.

Rodehutscord, M., Kapocius, M., Timmler, R., & Dieckmann, A. (2004). Linear regression approach to study amino acid digestibility in broiler chickens. *British Poultry Science*, 45, 85-92.

SAS (2004). SAS User's Guide. Statistics. Version 9.2. SAS Institute Inc., Cary, NC.

Sauer, W.C., Fan, M.Z., Mosenthin, R., & Drochner, W. (2000). Methods for measuring ileal amino acid digestibility in pigs, in: D'Mello, JPF (Ed.) Farm Animal Metabolism and Nutrition, pp. 279-306, CAB International, Wallingford, UK.

Short, F.J., Wiseman, J., & Boorman, K.N. (1999). Application of a method to determine ileal digestibility in broilers of amino acids in wheat. *Animal Feed Science and Technology*, 79, 195-209.

Siriwan, P., Bryden, W.L., Mollah, Y., & Annison, E.F. (1993). Measurement of endogenous amino acid losses in poultry. *British Poultry Science*, 34, 939-949.

Sibbald, I.R. (1986). The TME system of feed evaluation: methodology, feed composition data and bibliography. Technical Bulletin 1986-4E. Animal Research Center, Research Branch, Agriculture Canada, Ottawa, Canada.

Sibbald, I.R. (1987). Estimation of bioavailable amino acids in feedstuffs for poultry and pigs: A review with emphasis on balance experiments. *Canadian Journal of Animal Science*, 67, 221-300.

Tarvid, I. (1995). The development of protein digestion in poultry. *Poultry and Avian Biology Reviews*, 6, 35-54.

Williams, C.H. David, D.J., & Iismaa, O. (1962). The determination of chromic oxide in feces samples by atomic absorption spectrophotometry. *Journal of Agricultural Science*, 59, 381-385.

Zuprizal, M.L., & Chagnea, A.M. (1992). Effect of age and sex on true digestibility of amino acids of rapeseed and soybean meals in growing broilers. *Poultry Science*, 71, 1486-1492.

تحقیقات کشاورزی ایران (۱۳۹۵) ۳۵(۲) ۴۱- ۴۶

تعیین گوارش پذیری استاندارد پیش سکومی پروتئین کنجاله کلزا در بوقلمون های نژاد انگلیسی بیگ-۶ در سنین مختلف، با استفاده از روش رگرسیون خطی چند متغیره

محمد رضا رضوانی*، امیراخلاقی، فاطمه صائمی، محمد مهدی امتی، محمد دادپسند، هادی آتشی

گروه علوم دامی، دانشکده کشاورزی، دانشگاه شیراز، شیراز، ج. ا. ایران.

*نویسنده مسئول

اطلاعات مقاله

تاریخچه مقاله:
تاریخ دریافت: ۱۳۹۳/۷/۷
تاریخ پذیرش: ۱۳۹۴/۱۲/۲
تاریخ دسترسی: ۱۳۹۵/۴/۲۷

واژه های کلیدی:
گوارش پذیری استاندارد پروتئین
رگرسیون چند متغیره
کنجاله کانولا
بوقلمون های نژاد انگلیسی بیگ ۶

چکیده– نود و شش قطعه بوقلمون نژاد انگلیسی بیگ-۶ در سن ۲ هفتگی به دو گروه (هر گروه شامل۴ تکرار و هر تکرار ۱۲ پرنده) تقسیم شدند. یک جیره ی پایه و یک جیره ی دارای ۲۰ درصد کنجاله کانولا که جانشین نشاسته ی ذرت در جیره ی پایه شده بود، آماده شدند. در سن ۹، ۱۶ و ۲۱ هفتگی چهار پرنده از هر تکرار برای جمع آوری مواد هضمی روده کشتار شدند. قطعه‌ی دو سوم انتهایی روده حدفاصل زایده مکل و ۲ سانتی متر قبل از محل اتصال ایلئوم به سکوم بریده شد. ماده ی خشک، پروتئین خام و مارکر خارجی اکسید کروم در جیره های غذایی و مواد هضمی اندازه گیری شدند. گوارش پذیری استاندارد پیش سکومی پروتئین کنجاله کانولا با روش رگرسیون چند متغییره محاسبه شد. گوارش پذیری استاندارد پیش سکومی پروتئین کنجاله کانولا در سن ۲۱ هفتگی به طور معنی داری کمتر از سن ۹ هفتگی بود و وزن نسبی اندامهای گوارشی نیز روند کاهشی معنی داری را با افزایش سن نشان داد ($P< 0.05$). با وجود تصحیح انجام شده برای نیتروژن دارای منشاء داخلی در روش رگرسیون خطی چند متغییره، مشاهده شد که گوارش پذیری استاندارد پیش سکومی پروتئین کنجاله کانولا تحت تاثیر سن پرنده قرار دارد.