The Influence of Cecectomy on Metabolizable Energy and Amino Acid Digestibility of Select Feedstuffs for White Pekin Ducks

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ABSTRACT Twenty-four cecectomized and 24 intact White Pekin ducks were used in two experiments to assess the influence of cecectomy on ME and amino acid digestibility of several feed ingredients for ducks. Corn and soybean meal (SBM) were evaluated in Experiment 1, and bakery meal (BM), red dog (RD), and wheat middlings (WM) were evaluated in Experiment 2. Nitrogen-corrected true metabolizable energy and amino acid digestibility of the ingredients were assayed concurrently. In Experiment 1, TME of corn was higher ($P \leq 0.05$) in cecectomized ducks, and intact ducks demonstrated greater ($P \leq 0.05$) ability to utilize the energy in SBM. Intact ducks exhibited higher ($P \leq 0.05$) true digestibilities of lysine and methionine. True digestibility of tryptophan was higher ($P \leq 0.05$) for cecectomized ducks. True digestibility of indispensable amino acids in SBM did not differ ($P \geq 0.05$) between cecectomized and intact ducks. In Experiment 2, cecectomized ducks exhibited greater ($P \leq 0.05$) ability to utilize the energy in RD. Intact ducks exhibited greater ($P \leq 0.05$) ability to utilize the energy in WM. True digestibility of indispensable amino acids in BM, RD, and WM was variable. Results of the present study suggest that the effect of cecectomy on nutrient digestibility in ducks is dependent on the feedstuff assayed.

(*Key words*: duck, cecectomy, metabolizable energy, amino acid, digestibilities)

1999 Poultry Science 78:707–713

INTRODUCTION

Studies evaluating amino acid digestibility of feed ingredients using cecectomized chickens are numerous (Payne *et al*., 1971; Sibbald, 1979a,b; Parsons, 1985; Johns *et al*., 1986; and Green *et al*., 1987a,b). Information gleaned from these studies can be utilized by poultry nutritionists to formulate diets with increased precision in order to satisfy the amino acid requirements of chickens. Amino acid digestibility studies in ducks have been conducted (for review, see Elkin, 1987), but to the authors' knowledge, no studies employing cecectomized ducks have been reported. Historically, balance studies have posed a problem in ducks due to difficulties in excreta collection (Ostrowski-Meissner, 1984). Recent ME experiments completed with ducks (Adeola *et al*., 1997; King *et al*., 1997; and Ragland *et al*., 1997) have described a surgical collection method which minimizes the problems associated with excreta collection in ducks and increases the precision of the TME bioassay. A series of experiments by Sibbald (1979a) demonstrated that amino acid excretion associated with a feedstuff is independent of energy intake. Thus, based on improvements in excreta collection methodology for ducks, the TME bioassay can be used with confidence for estimating amino acid digestibility in feedstuffs. The goals of the present research was twofold: to evaluate the effect of cecectomy on TME and amino acid digestibilities of feed ingredients used in diet formulation for ducks; and to describe a procedure for cecectomy in ducks.

MATERIALS AND METHODS

The modified TME bioassay described by McNab and Blair (1988) was used in two experiments to evaluate the effect of cecectomy on energy bioavailability and amino acid digestibility of feed ingredients used in diet formulation for ducks. In each experiment, 24 cecectomized and 24 intact, male, White Pekin ducks of approximately 36 wk of age were sorted according to weight and placed in individual cages (0.66 m × 0.66 m). The cages were maintained in an environmentally controlled room (25 C) under a 24-h light cycle. In Experiment 1, 16 ducks (8 cecectomized, 8 intact) were

Received for publication October 5, 1998.
Accepted for publication January 16, 1999.
[1]Purdue University Agricultural Research Programs-Journal Paper Number 15798.
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Abbreviation Key: BM = bakery meal; RD = red dog; SBM = soybean meal; WM = wheat middlings.

assigned to each of two dietary treatments. Eight cecectomized and 8 intact ducks were also fed dextrose for estimation of endogenous losses of amino acids, energy, and nitrogen (Sibbald, 1979a). The treatments in Experiment 1 consisted of corn and soybean meal (SBM). In Experiment 2, 12 ducks (6 cecectomized, 6 intact) were assigned each of three dietary treatments. Six cecectomized and 6 intact ducks were also fed dextrose for estimation of endogenous losses of amino acids, energy, and nitrogen. The treatments in Experiment 2 were composed of bakery meal (BM), red dog (RD), and wheat middlings (WM). Red dog is a low-fiber by-product from flour milling composed primarily of wheat offal, with particulate contributions of wheat bran, germ and flour (Ensminger *et al.*, 1990).

Cecectomy Procedure

The cecectomy procedure described by Payne *et al.* (1971) for chickens was adapted and utilized in the present study. Because surgical alteration of all ducks was accomplished over a 2-wk period, ducks were approximately 32 to 34 wk of age at the time the surgeries were performed. Ducks selected to undergo the cecectomy procedure were deprived of feed for 24 h and water for approximately 12 h. General anesthesia was employed using Halothane™[3] gas. Ducks were induced and maintained under gas anesthesia using an anesthetic mask fabricated specifically for ducks within our laboratory.

A slow anesthetic induction was employed using 2% anesthetic gas and an oxygen flow rate of 2 L / min. Upon achieving a surgical plane of anesthesia, the oxygen flow rate remained constant at 2L / min, and the anesthetic gas was maintained between 1.75 to 2.00%. Systemic preoperative and postoperative antibiotic therapy was used to prevent infection and eliminate the need for daily injections of antibiotics postsurgery. Prior to preparation of the ducks for surgery, 300,000 IU of penicillin G procaine[4] was administered subcutaneously. After achieving a surgical plane of anesthesia, ducks were restrained in right lateral recumbency with the left leg pulled forward to facilitate access to the surgical site. The surgical site was prepared by plucking a zone of feathers in the area corresponding to the left flank to expose the underlying skin. The exposed skin was then sanitized with betadine scrub.[5] The ducks were then covered with a disposable surgical drape and a defect created in the drape to access the surgical site. Principles of aseptic surgery were observed to prevent complications of infection postsurgery; thus, surgical caps, surgical masks, and sterile gloves were worn during the procedures by all individuals present.

A horizontal skin incision originating at the caudal border of the left costal arch and extending caudally to the left pubic bone was made, exposing the underlying musculature. A small, horizontal incision was made in the muscle layer and the incision widened by blunt dissection, which was continued into the abdomen until the ceca could be seen. Care was taken to avoid incising the abdominal air sacs. Upon identifying the ceca, the abdomen was packed off with gauze sponges and the apex of each cecum exteriorized. The body of each cecum was freed from its ligamentous attachment by blunt dissection of the ileocecal ligament. Vessels within the ileocecal ligament were ligated with 2-0 chromic gut absorbable suture[6] or twisted off with hemostats to prevent hemorrhage postsurgery. The ceca were ligated with 2-0 chromic gut absorbable suture most proximal to the ileal junction and removed. The cecal stumps and abdomen were lavaged with normal saline[7] and the body wall closed in three layers; muscular, subcuticular, and skin. Immediately after completion of the procedure, 450,000 IU of Dual-Cillin (penicillin G procaine and penicillin G benzathine)™[8] was administered subcutaneously to maintain postoperative antibiotic blood levels. Ducks were allowed access to water upon recovery from anesthesia and allowed *ad libitum* access to feed 18 to 24 h postsurgery. Nonabsorbable skin sutures[9] were removed 14 d postsurgery. The cecectomy procedure utilized in the present study was approved by the Purdue University Animal Care and Use Committee.

Feeding and Collection Methodology

The feeding and collection methodology utilized in each experiment was adopted from the methods detailed by Adeola *et al.* (1997). The test ingredients in Experiment 2 were fed in 300 mL of distilled water and mixed in a blender due to the fibrous nature of the ingredients. The feeding and collection protocols were approved by the Purdue University Animal Care and Use Committee.

Chemical Analysis

Excreta samples were transferred to aluminum pans and placed in a 55 C oven for 120 h. After drying, excreta samples were ground through a 0.5-mm screen to facilitate analysis. Dry matter contents of the ingredients and excreta samples were determined by drying the samples at 110 C for 24 h. Amino acid composition of the test ingredients and excreta was determined by a commercial laboratory.[10] Nitrogen content of ingredients and excreta was determined by the combustion method using the LECO Model FP2000 combustion analyzer.[11] Energy content of the ingredients and excreta was determined by bomb calorimetry using a Parr 1261 adiabatic calorimeter.[12]

[3]Halocarbon Laboratories, River Edge, NJ 07661.
[4]Vedco Inc., St. Joseph, MO 64504.
[5]The Purdue Frederick Co., Norwalk, CT 06850.
[6]Anchor Products Co., Addison, IL 60101.
[7]Baxter Healthcare Corp., Deerfield, IL 60015.
[8]Phoenix Pharmaceutical, Inc., St. Joseph, MO 64506.
[9]Jorgensen Laboratories, Inc., Loveland, CO 80538.
[10]University of Missouri Experiment Station Chemical Labs, Columbia, MO 65211.
[11]LECO Corp., St. Joseph, MI 49085.
[12]Parr Instrument Co., Moline, IL 61265.

TABLE 1. Amino acid (AA), dry matter, crude protein, nitrogen, and gross energy contents of ingredients, Experiments 1 and 2

Item	Experiment 1		Experiment 2		
	Corn[1]	Soybean meal[1]	Bakery meal[1]	Red dog[1]	Wheat middlings[1]
	(%)				
Indispensable AA					
Arginine	0.35	3.60	0.47	1.12	0.99
Histidine	0.22	1.29	0.26	0.45	0.41
Isoleucine	0.25	2.14	0.43	0.56	0.49
Leucine	0.90	3.69	0.89	1.09	0.96
Lysine	0.24	3.05	0.24	0.66	0.63
Methionine	0.17	0.68	0.19	0.29	0.24
Phenylalanine	0.36	2.42	0.58	0.72	0.61
Threonine	0.27	1.84	0.35	0.54	0.49
Tryptophan	0.05	0.69	0.12	0.20	0.19
Valine	0.35	2.26	0.53	0.81	0.72
Dispensable AA					
Alanine	0.55	2.05	0.43	0.76	0.71
Aspartate	0.49	5.39	0.58	1.14	1.04
Cysteine	0.18	0.72	0.29	0.36	0.36
Glutamate	1.34	8.54	3.54	3.60	2.91
Glycine	0.29	2.00	0.45	0.78	0.78
Proline	0.61	2.21	1.29	1.22	0.99
Serine	0.33	2.01	0.50	0.62	0.54
Tyrosine	0.22	1.66	0.30	0.42	0.40
Dry matter	87.41	87.46	89.80	86.12	89.07
Crude protein	7.38	48.02	12.63	17.94	15.75
Nitrogen	1.18	7.69	2.02	2.87	2.52
Gross energy, kcal/g	3.884	4.179	4.280	4.004	4.093

[1]Dry matter, crude protein, nitrogen, and gross energy values based on duplicate chemical analyses.

Statistical Analysis

Statistical analysis of the data was accomplished using the GLM procedure of SAS® (SAS Institute, 1989) based on a factorial arrangement of treatments. The randomized complete block design was employed to improve the precision of the respective assays. The least significant difference test was used to elucidate differences between treatment means.

RESULTS

Experiment 1

Amino acid, dry matter, crude protein, nitrogen, and gross energy contents of corn and SBM fed in Experiment 1, and BM, RD and WM fed in Experiment 2 are listed in Table 1. Feed-deprived, intact ducks experienced greater losses in weight during the assay (data not shown), and cecectomized ducks were observed to have greater endogenous losses of nitrogen, energy, and 13 amino acids (Table 2). True metabolizable energy of corn was greatest ($P \leq 0.05$) for cecectomized ducks. Intact ducks exhibited greater ($P \leq 0.05$) ability to metabolize the energy in SBM based on TME. Intact ducks had higher ($P \leq 0.05$) true digestibilities of lysine, methionine, alanine, and glutamate in corn (Table 3). Cecectomized ducks exhibited a higher ($P \leq 0.05$) true digestibility of tryptophan. Cecectomy failed to influence true digestibility of indispensable and dispensable amino acids in SBM, as no differences ($P \geq 0.05$) were observed between cecectomized and intact ducks.

Experiment 2

Feed-deprived, cecectomized ducks experienced greater losses in weight (data not shown) and were observed to have greater endogenous losses of nitrogen, energy, and all indispensable and dispensable amino acids measured (Table 4). True digestibilities of amino acids in BM, RD, and WM are presented in Table 5. Cecectomized ducks experienced higher energy excretion, but the differences were significant ($P \leq 0.05$) only for BM and WM. Intact ducks exhibited greater ($P \leq 0.05$) ability to utilize energy contained in WM as evidenced by the TME and TME_n for WM. After correction for endogenous losses of energy, the TME of RD was higher ($P \leq 0.05$) for cecectomized ducks. Intact ducks fed BM had higher ($P \leq 0.05$) true digestibilities of histidine and lysine after correction for endogenous losses of amino acids (Table 5). No differences ($P \geq 0.05$) in true amino acid digestibility for cecectomized or intact ducks were observed for RD. Cecectomized ducks had higher ($P \leq 0.05$) true digestibilities of leucine, phenylalanine, threonine, tryptophan, and tyrosine in WM.

DISCUSSION

Preliminary work with injectable anesthetic protocols (Ludders *et al.*, 1989) yielded disappointing results in

TABLE 2. Endogenous outputs of energy, nitrogen, and amino acids (AA) by surgical factor, Experiment 1[1]

Item	Cecectomy[2]	SD	Intact[2]	SD
Nitrogen output, g	1.83	0.177	1.26	0.429
Energy output, kcal	44.00	6.90	27.00	6.60
Indispensable AA output, mg				
Arginine	54.00	7.00	48.00	6.60
Histidine	26.70	3.40	26.00	5.20
Isoleucine	45.00	5.40	44.50	10.10
Leucine	83.20	11.10	71.00	12.70
Lysine	59.00	11.60	61.00	17.30
Methionine	13.30	1.10	16.00	5.20
Phenylalanine	50.30	8.60	42.50	7.90
Threonine	79.00	7.00	57.80	9.00
Tryptophan	17.90	3.80	11.30	2.70
Valine	67.90	10.90	65.30	12.90
Dispensable AA output, mg				
Alanine	89.40	18.50	98.80	36.40
Aspartate	95.30	9.50	88.00	20.20
Cysteine	45.70	5.50	40.30	4.80
Glutamate	11.50	11.80	11.50	33.90
Proline	80.10	9.50	62.00	7.60
Serine	57.30	5.20	42.50	4.80
Tyrosine	45.40	7.50	35.00	6.20
n	6		8	

[1]Nitrogen, energy, and amino acid outputs based on a 54-h collection period.

[2]Mean nitrogen and energy values based on duplicate chemical analyses.

terms of analgesia; thus, gas anesthesia was utilized for the cecectomy procedure reported herein. Halothane was used based on observations of superior analgesia in comparison to injectable anesthetics, and speed of anesthetic induction. Associated complications of premature and prolonged recovery from anesthesia as described by Gurnsey *et al.* (1985) were not encountered. Ducks recovering from anesthesia were observed to consistently regurgitate material that probably originated from the lower gut due to the 24-h feed restriction prior to the surgical procedure. Intraoperative antibiotic therapy and use of aseptic technique appeared to

TABLE 3. Energy utilization and true digestibility of amino acids (AA) in corn and SBM, Experiment 1

	Corn		Soybean meal		
Item	Cecectomy	Intact	Cecectomy	Intact	SD
Energy					
Intake, kcal	232.80	232.80	250.70	250.70	
Output, kcal	39.60^{b}	36.90^{b}	85.10^{a}	87.20^{a}	3.75
TME	3.889^{a}	3.801^{b}	3.422^{b}	3.530^{c}	0.078
TME_n	3.644^{a}	3.575^{b}	2.954^{b}	2.978^{b}	0.098
Indispensable AA, %					
Arginine	83.30^{b}	84.50^{b}	97.00^{a}	96.10^{a}	5.07
Histidine	94.30^{a}	95.40^{a}	95.80^{a}	96.10^{a}	2.37
Isoleucine	75.70^{b}	79.60^{b}	93.00^{a}	92.30^{a}	5.67
Leucine	89.80^{b}	89.90^{b}	94.30^{a}	92.60^{a}	2.92
Lysine	74.10^{c}	79.30^{b}	94.10^{a}	94.20^{a}	3.72
Methionine	84.80^{c}	87.30^{b}	91.40^{a}	90.30^{a}	2.09
Phenylalanine	87.00^{b}	87.10^{b}	95.40^{a}	93.90^{a}	3.93
Threonine	88.00^{b}	85.10^{b}	93.50^{a}	91.70^{a}	5.09
Tryptophan	122.70^{a}	109.70^{b}	98.10^{c}	97.90^{c}	5.56
Valine	76.70^{b}	80.10^{b}	91.60^{a}	90.60^{a}	6.86
Dispensable AA, %					
Alanine	90.90^{b}	95.70^{a}	88.00^{b}	89.00^{b}	3.30
Aspartate	74.80^{b}	79.10^{b}	93.70^{a}	93.50^{a}	4.62
Cysteine	76.30^{b}	85.20^{b}	90.40^{a}	90.30^{a}	15.17
Glutamate	86.80^{c}	89.50^{b}	94.10^{a}	94.60^{a}	2.20
Proline	90.50^{a}	90.90^{a}	95.70^{a}	94.20^{a}	5.92
Serine	81.10^{b}	84.30^{b}	93.80^{a}	92.10^{a}	7.04
Tyrosine	85.60^{b}	85.00^{b}	95.40^{a}	93.30^{a}	5.18
n	8	8	7	8	

[a–c]Means in each row with no common superscript differ significantly ($P \leq 0.05$).

TABLE 4. Endogenous outputs of nitrogen, energy, and amino acids (AA) by surgical factor, Experiment 2[1]

Item	Cecectomy[2]	SD	Intact[2]	SD
Nitrogen output, g	1.10	0.552	0.68	0.289
Energy output, g	30.00	6.90	23.00	6.30
Indispensable AA output, mg				
Arginine	63.80	19.80	51.30	5.80
Histidine	26.50	7.60	24.30	2.60
Isoleucine	70.20	22.90	63.30	22.40
Leucine	120.50	38.00	89.20	14.20
Lysine	48.70	12.80	41.30	4.00
Methionine	15.20	5.20	13.20	3.30
Phenylalanine	67.00	15.90	51.00	7.20
Threonine	101.70	25.50	76.80	12.80
Tryptophan	12.00	3.30	10.00	2.30
Valine	92.70	23.20	73.80	10.20
Dispensable AA output, mg				
Alanine	116.50	34.90	97.50	20.50
Aspartate	127.80	34.90	108.00	21.50
Cysteine	59.30	25.20	47.50	7.00
Glutamate	148.00	31.90	120.20	30.10
Proline	86.80	30.40	67.50	11.40
Serine	77.00	23.40	59.50	13.40
Tyrosine	58.00	17.70	41.50	8.20
n	6		6	

[1]Nitrogen, energy, and amino acid outputs based on a 54-h collection period.

[2]Mean nitrogen and energy values based on duplicate chemical analyses.

prevent the development of postoperative infections. The descriptions of the cecectomy procedure by Payne *et al.* (1971) and Green *et al.* (1987a) did not discuss the significance of hemostasis in the chicken, but hemostasis in the duck did require considerable attention. The vessels in the ileocecal ligament were highly vascular and required ligation with suture, or twisting off of the vessels with hemostats to encourage clot formation. The result of inattention to hemostasis was postoperative hemorrhage and death. Ducks were allowed *ad libitum* access to feed within 24 h postsurgery because impairment of gastrointestinal function was not observed in

TABLE 5. Energy utilization and true digestibility of amino acids (AA), bakery meal, red dog, and wheat middlings, Experiment 2

	Bakery meal		Red dog		Wheat middlings		
Item	Cecectomy	Intact	Cecectomy	Intact	Cecectomy	Intact	SD
Energy							
Intake, kcal	256.80	256.80	240.20	240.20	245.60	245.60	
Output, kcal	37.50^{d}	32.00^{e}	77.70^{c}	76.30^{c}	113.10^{a}	96.90^{b}	4.49
TME	4.158^{a}	4.130^{a}	3.213^{b}	3.117^{c}	2.711^{e}	2.859^{d}	0.074
TME_n	3.918^{a}	3.933^{a}	2.948^{b}	2.900^{b}	2.502^{d}	2.673^{c}	0.071
Indispensable AA, %							
Arginine	87.40^{b}	89.90^{ab}	90.40^{ab}	90.40^{ab}	90.60^{a}	87.50^{ab}	3.14
Histidine	90.50^{b}	93.50^{a}	90.00^{b}	91.90^{ab}	89.60^{b}	88.40^{b}	2.58
Isoleucine	90.70^{a}	94.10^{a}	84.80^{b}	86.90^{b}	84.90^{b}	82.60^{b}	4.87
Leucine	94.20^{a}	93.60^{a}	88.10^{b}	86.60^{b}	88.80^{b}	82.00^{c}	4.25
Lysine	54.80^{c}	61.50^{b}	73.60^{a}	77.80^{a}	76.50^{a}	74.10^{a}	5.79
Methionine	86.00^{a}	86.90^{a}	79.80^{b}	81.50^{b}	78.30^{bc}	74.90^{c}	4.00
Phenylalanine	94.10^{a}	94.30^{a}	89.10^{b}	88.10^{b}	89.50^{b}	83.60^{c}	3.67
Threonine	100.00^{a}	98.50^{a}	91.60^{b}	89.20^{bc}	93.00^{b}	85.40^{c}	5.74
Tryptophan	100.80^{a}	103.40^{a}	92.70^{bc}	94.10^{b}	94.00^{b}	90.50^{c}	3.36
Valine	88.80^{ab}	91.00^{a}	84.10^{b}	84.20^{b}	83.00^{b}	80.00^{b}	4.80
Dispensable AA, %							
Alanine	94.50^{a}	95.60^{a}	79.90^{b}	81.60^{b}	78.60^{b}	76.90^{b}	6.26
Aspartate	81.40^{ab}	85.70^{a}	80.80^{ab}	82.50^{ab}	81.70^{ab}	78.60^{b}	5.07
Cysteine	97.70^{ab}	103.30^{a}	94.10^{ab}	90.30^{b}	90.70^{b}	89.10^{b}	11.04
Glutamate	94.90^{a}	95.30^{a}	91.80^{b}	92.40^{b}	90.80^{bc}	89.50^{c}	1.88
Proline	94.80^{ab}	98.50^{a}	95.30^{ab}	94.90^{ab}	94.00^{b}	92.40^{b}	3.96
Serine	94.20^{ab}	95.20^{a}	92.80^{ab}	90.30^{ab}	89.00^{b}	85.00^{b}	5.51
Tyrosine	92.20^{a}	91.80^{a}	88.00^{ab}	85.20^{b}	91.00^{a}	81.70^{b}	5.37
n	6	6	6	6	6	5	

[a–c]Means in each row with no common superscript differ significantly ($P \leq 0.05$).

preliminary work, and the lumen of the intestine was not compromised as a result of the surgery.

The feeding and collection methods used in the study have been extensively tested in our lab and have been found to be very reliable for estimating the ME of a variety of feedstuffs in ducks. Regressing amino acid excretion from SBM on glucose input, Sibbald (1979a, 1987) concluded that the TME bioassay is a dual purpose assay based on the observation that energy input does not influence amino acid excretion. Thus, amino acid digestibility data can be derived with confidence when the TME bioassay is used to generate such data in ducks. A review of poultry digestibility principles and applications by Johnson (1992) suggests that cecectomized birds should definitely be used in amino acid digestibility studies when the feedstuffs to be assayed are characterized by questionable amino acid digestibility.

The general effects of cecectomy observed in the present experiments are consistent with results described for cecectomized chickens by various authors. Parsons (1985) observed that cecectomized roosters excreted higher amounts of energy and amino acids and tended to have lower amino acid digestibility coefficients than intact chickens. Johns *et al.* (1986) noted a similar effect of depressed amino acid digestibility in studies with cecectomized roosters. The amino acid output data in the present experiments, compared to that of Green *et al.* (1987a) for roosters, would suggest that feed-deprived ducks excrete amino acids in considerably greater quantities than chickens.

The amino acid digestibility of corn in Experiment 1 paralleled results obtained by Green *et al.* (1987a) for certain amino acids. Compared to true amino acid digestibility coefficients determined by Sibbald (1979b), Green *et al.* (1987a), Cave (1988), and compiled by Parsons (1992, 1996) from several studies, it appears that chickens digest amino acids in corn with greater efficiency than ducks. Based on work by several researchers with oil seeds, the results obtained in Experiment 1 would imply that ducks digest the amino acids in SBM more efficiently than chickens. True amino acid digestibility coefficients determined for SBM in the present study exceeded the true digestibility coefficients determined by Green *et al.* (1987b) and compiled by Parsons (1992, 1996). True amino acid digestibility coefficients for SBM determined by Cave (1988) approximated those determined in the present study. Although cecectomy failed to exert an effect on true amino acid digestibility of SBM, decreased energy utilization by cecectomized ducks was observed. Collectively, energy output for corn and SBM did not differ between cecectomized and intact ducks. The effect of dietary energy residues in the lower gut promoting microbial proliferation and facilitating increased microbial degradation and utilization of amino acids within the ceca of intact birds is unclear. However, Parsons (1985) did document a higher contribution of microbial protein in excreta of intact roosters compared to cecectomized roosters.

By-products from wheat milling and the baking industry have frequently been evaluated to determine their feeding value for chickens (Patterson *et al.*, 1988; Saleh *et al.*, 1996). Although acceptable results have been obtained in studies with chickens, no studies in ducks have been reported. Dried BM is considered to be a high-quality feed ingredient because of its intended use for human consumption (Dale, 1996). As in Experiment 1, the trend of greater amino acid excretion in feed-deprived, cecectomized ducks was observed in Experiment 2. Variation in true amino acid digestibility of BM was minimal as differences in digestibility were observed only for histidine and lysine. Taking into consideration that products like BM can be prone to variation in nutrient composition based on the level of refinement (Dale, 1996), true digestibility coefficients compiled by Parsons (1992) suggests that amino acids in BM are digested with similar efficiency in ducks and chickens.

True amino acid digestibility of RD was unremarkable for cecectomized and intact ducks. The amino acid digestibility pattern of RD closely resembled that of WM, suggesting similarity in the composition of the products. Wheat middlings are a blended product consisting primarily of wheat bran, wheat germ, flour, wheat shorts, and minor contributions of wheat offal (Ensminger *et al.*, 1990). The amino acid digestibility of WM was noteworthy, as cecectomized ducks demonstrated higher true digestibility of all amino acids measured. A fiber effect of WM on amino acid digestibility is questionable, but enhancement of digestibility in cecectomized birds would not be consistent with this effect. True digestibility coefficients determined by Cave (1988) indicate that ducks and chickens digest amino acids in WM with similar efficiency. Energy output and ME of BM, RD, and WM did conform to observations by Parsons (1985) in chickens, with cecectomized ducks excreting greater quantities of energy and exhibiting decreased ability to utilize energy in the feedstuffs.

The higher amino acid digestibility coefficients in intact birds is speculated to be due to greater microbial degradation and utilization in the lower gut, cecal retention of amino acids, or both (Parsons, 1985). The differences in amino acid digestibility between cecectomized and intact birds is postulated to be a reflection of the ability of intact birds to metabolize endogenous amino acids arising from physiologic processes. Thus, the microbial population of the ceca should have no direct effect on digestion and utilization of dietary amino acids (Sibbald, 1979a). The amino acid output data of the present experiments appear to support this opinion based on differences in output of threonine and proline between cecectomized and intact ducks. Threonine and proline are considered to reflect an endogenous, rather than dietary contribution to the

excreta, and was observed in greater quantities in the excreta of cecectomized ducks.

The present study demonstrates that the effect of cecectomy is dependent on the feedstuff under consideration, and that the general effects of cecectomy are similar for ducks and chickens. In addition, the results of our work with ducks support the opinion of Johnson (1992) that cecectomized poultry should be used in amino acid digestibility studies to prevent overestimation of digestibility of amino acids in feedstuffs.

ACKNOWLEDGMENTS

The valuable assistance provided by Kay Hostetler, Dale King, and Stacey Selin, and the generous donation of ducks and feed by Maple Leaf Farms, Syracuse, IN 46567 are gratefully acknowledged.

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